SCIENTIFIC AMERICAN SUPPLEMENT. No. 1777

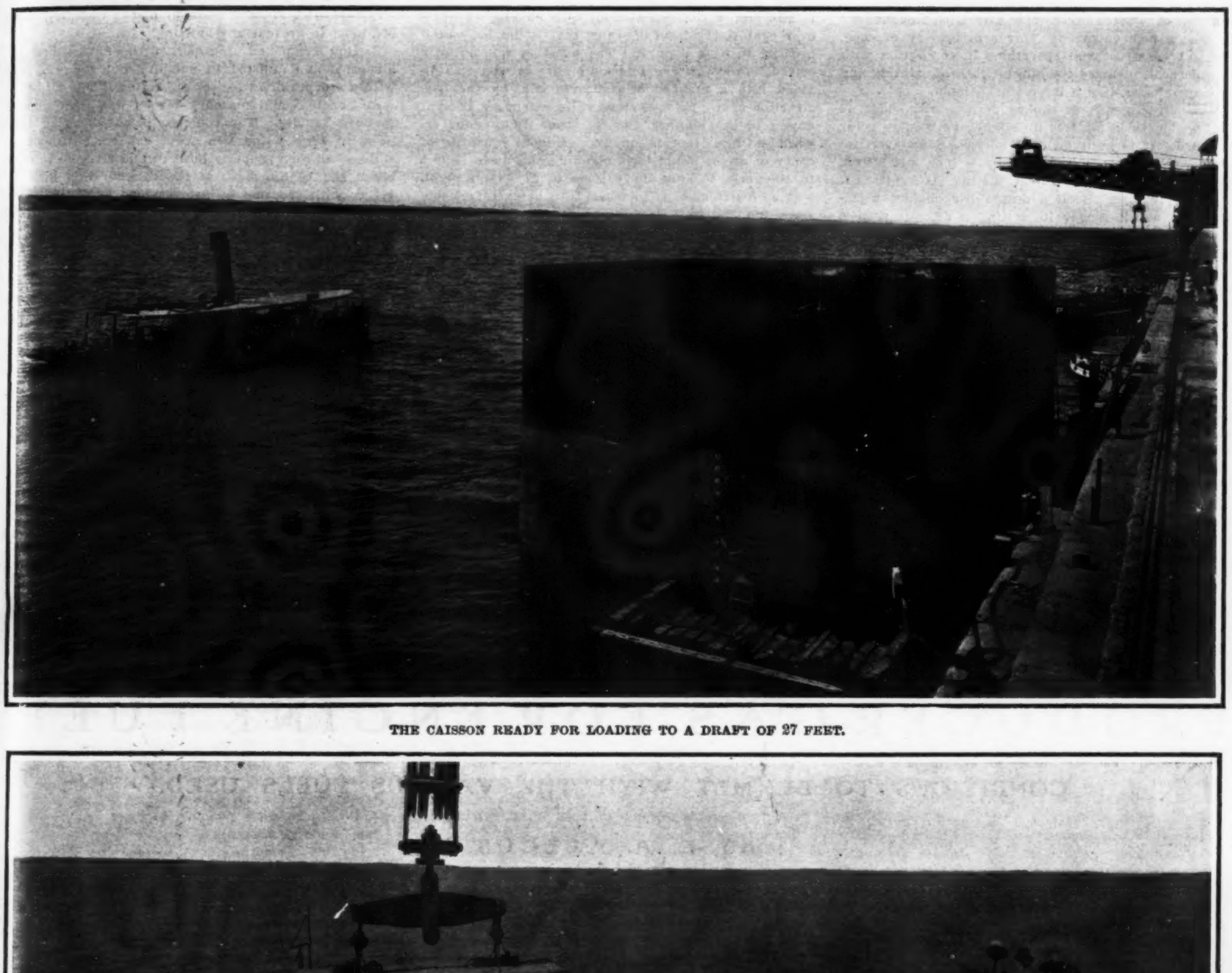
Entered at the Post Office of New York, N. Y., as Second Class Matter.

Published weekly by Munn & Co., Inc., at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

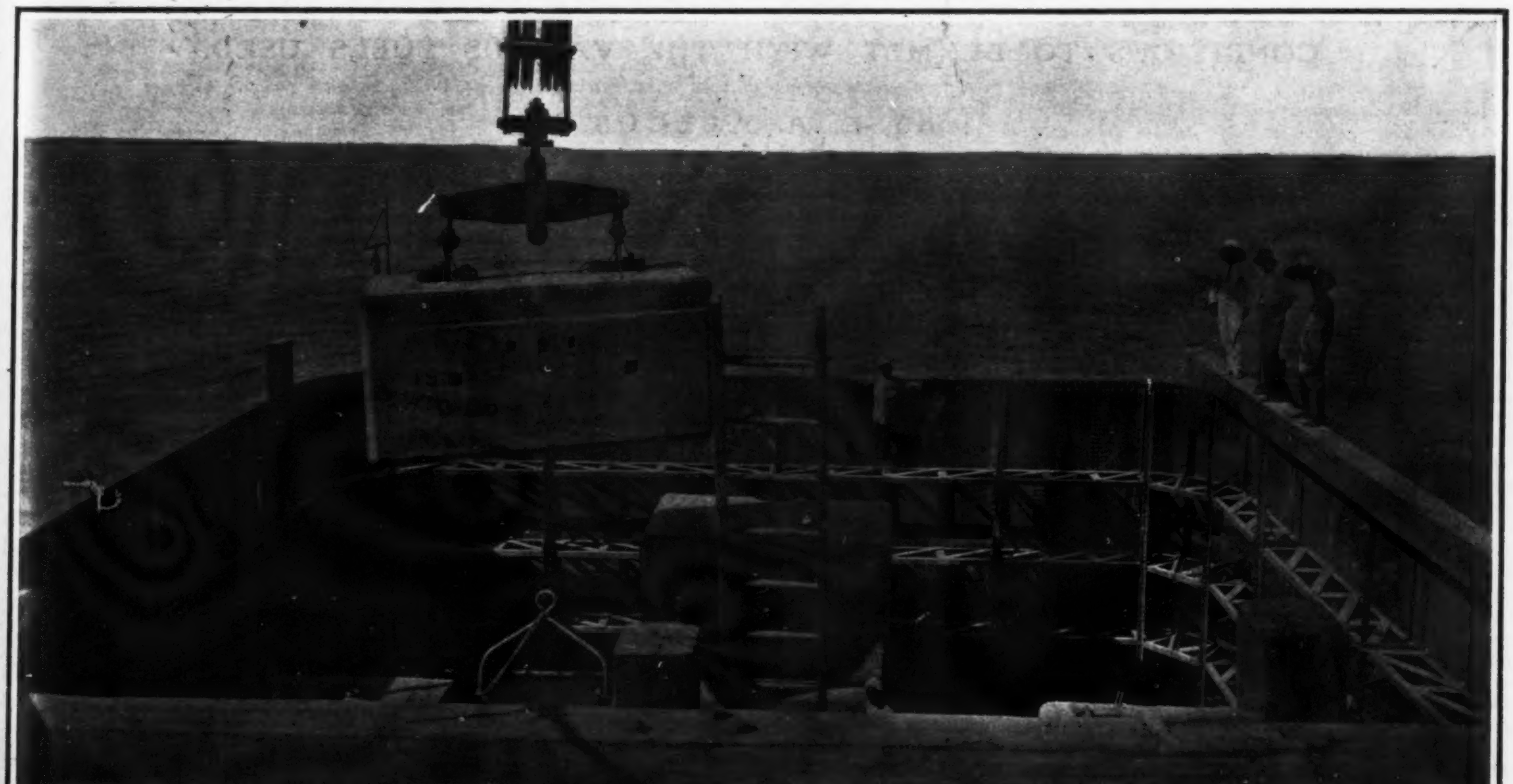
Scientific American, established 1845.
Scientific American Supplement, Vol. LXIX., No. 1777.

NEW YORK. JANUARY 22. 1910.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



THE CAISSON READY FOR LOADING TO A DRAFT OF 27 FEET.



FILLING THE CAISSON WITH CONCRETE BLOCKS AT THE PIERHEAD.

THE MADRAS HARBOR WORKS. SINKING THE PIERHEAD CAISSON.

THE MADRAS HARBOR WORKS.

SINKING THE PIERHEAD CAISSON.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

SOME years ago the deplorable facilities at Madras harbor were such as to cause shipping to avoid the port as much as possible. When finally a new board was organized, the chairman, Mr. J. F. E. Spring, C.I.E., resolved upon a comprehensive improvement scheme which has been in progress for some years past, and is now nearing completion. The work included the erection of a north breakwater arm 1,500 feet long, to protect a new entrance. This arm is very exposed, and the constructional operations in connection with the pierhead involved the difficult task of erecting and setting into position a large iron caisson.

This structure is of square design, with sides 42 feet in length by 51 feet in height, the corners being rounded. It is built up of a horizontal and vertical framework of 3-inch by 3-inch by ⅝-inch angle iron, the shell comprising ¼-inch plating. Complete, it weighs 110 tons. Such a design has obvious disadvantages which render its setting a difficult matter, inasmuch as a caisson with flat sides is not so capable as the circular form of resisting such a considerable head of water as is here experienced. Consequently, the work necessitated unremitting care and skill.

The structure was built up on the slipway. When riveted up to a height of 23 feet, it was successfully launched. The caisson was then towed and moored alongside a wharf, where the remaining 38 feet of its height was completed, the structure being turned round, so that one side at a time could be easily handled. While this part of the work was in progress a bed of concrete was laid over its bottom, 15 inches in thickness, and following the contour of all the sides in the shape of a wall 12 inches thick. When the shell was completed and the flooring finished, the structure drew 6 feet of water and displaced 325 tons. At this juncture the caisson was towed to a convenient point near the pierhead, so as to come within range of the 30-ton titan crane used in the breakwater constructional work. Here more concrete was added until the caisson drew 27 feet of water. It was then ready to be set into position.

This part of the work offered many perplexing problems. The crucial question was how to dispose the concrete within the caisson so as to sink it to a depth of 27 feet in the water in such a way that the fragile sides might secure the maximum of stiffening with the minimum of concrete. Had the concrete been spread in a mass on the bottom, 11 feet of it would have been sufficient to sink the structure to the requisite 27 feet. In this case there would have been left 16 feet of thin metal shell with no support whatever against the head of water that would have been brought to bear upon it. The question was adroitly solved, however. The interior of the caisson was divided into a number of compartments, by the construction of two pairs of cross walls, extending at right angles to one another, the thickness diminishing toward the top. In this manner the same quantity of concrete which would have given a solid mass 11 feet in thickness to sink the caisson to 27 feet draught, was so distributed as to reach to a height of 26 feet from the bottom. Hence the sides were adequately strengthened.

While this work was in progress, the preparation of the foundations for the caisson at the pierhead was undertaken. A rubble bed measuring 47 feet each way and 11 feet deep had been completed, and its top surface carefully leveled by divers. When this was completed, four 15-inch vertical timbers were strutted back to the end of the masonry work, to serve as a guide face in setting the caisson.

When the caisson was sunk to a depth of 27 feet, its displacement was 1,350 tons. The towing of the structure to the site was a delicate task. As calm a day as possible was selected for the operation. This was successfully accomplished. Elaborate precautions had been adopted to hold the caisson firmly in position while the final settling was in progress. For this purpose two 100-ton lighters were moored about 200 feet on either side, and chains passing around winches on the lighters' decks served to hold it firmly *in situ* or to shift the caisson one way or the other as desired. In order to control the movement up to the vertical timbers, ropes were passed around the caisson and through tackle to the winches of the port 1,000-ton dredger. By pulling on these ropes the caisson was tightly jammed against the vertical guide timbers. Any displacement in any direction could thus have been easily and quickly readjusted.

When all was ready water was admitted into the caisson to sink it on the site. The structure rapidly settled down on the prepared bed. Directly this was accomplished, the titan crane temporarily loaded the structure with 27 solid masonry blocks weighing some 900 tons, to prevent any shifting.

Setting completed, the port dredger was brought alongside and assisted in pumping out the water to within a depth of 12 feet of the bottom. The filling in with concrete and masonry blocks was then pushed forward rapidly. The concrete blocks inserted temporarily were withdrawn from one compartment at a time and then properly built in and strutted to each other and to the sides of the caisson, this task together with grouting being continued until the whole structure had been filled to the top of the strutting girders, which were then built into the concrete. In this manner a depth of 24 feet from the bottom of the caisson was completed. For the succeeding 12 feet of height blocks measuring 14 feet long by 6 feet wide and deep respectively, and 10 feet long by 6 feet wide and deep respectively, were built in alternately to break the bond, all being bedded in mortar and filled around with 6 to 1 concrete. The skin of the caisson and the side walls was strutted to the blocks as the concrete was continued upward, the opposite faces of the caisson being clamped together at the level of 36 feet above the bottom by chains and unions, which were subsequently built into the structure. When the 36-foot level was gained, the surface was leveled off so as to form a bed for the granite-faced blocks forming the pierhead above the water level.

After being sunk the filling of the caisson to the 36-foot level occupied seventeen days, in which period 2,713 tons of concrete was built into the structure, giving a net weight resting upon the foundations of 2,138 tons. When the superstructure is completed the weight will aggregate 3,800 tons. The completion of these improvements will provide the port of Madras with one of the most up-to-date harbors in India.

PRODUCER-GAS FOR ENGINE FUEL.*

CONDITIONS TO BE MET WITH THE VARIOUS FUELS USED.

BY E. A. ALLCUT.

DURING the last few years, the application of gas power for engine work has been rapidly extending. The increase in the use of gas for the purpose of power generation has been as noticeable in the smaller units of 100 horse-power and under as in the larger installations. This continued demand for small units is all the more striking when we consider the favorable rates at which electrical energy is available for power purposes in most of the English towns. It would seem, at first sight, a hopeless undertaking for the small power user to generate his own supply in face of such formidable competition. The success of the gas-driven plant under such adverse conditions is due to improvements in the gas producer, rather than to the adoption of any new principles in the engine itself.

In all industrial companies cheap power is an important desideratum. The demand of the majority of manufacturers is comparatively low, and as steam-driven units of small size are rather uneconomical, the choice usually lies between electricity or gas from the public supply and private generation from a gas producer. The first two are usually only available at cheap rates in large towns, while the tendency is for manufacturers to remove their works to districts a few miles away where land is cheap and taxes are low. Above 500 horse-power, however, the steam engine begins to be a serious competitor to the gas engine, as, with high powers, its efficiency is greatly increased and the difference between it and the gas engine is by no means so marked as in the smaller units. The use of large producer-gas plants appears, nevertheless, to be gaining ground, though, in view of these and other considerations, more slowly than that of the smaller types. Gas engines of large size, 1,000 horse-power and over, have not, up to the present, been successfully worked on producer-gas. The large reciprocating weights in the standard double-acting engine, together with the tarry matter present in the gas, present great difficulties which practically preclude its use with a rich gas. These difficulties may be overcome in the future, but for the present the large gas engine has only a limited application. There is, however, a useful sphere of service open to it in connection with the blast furnaces of our iron districts. The poor gas of 70 to 100 B.t.u. per cubic foot, given off from the furnaces, can be, and is, very often used in these large engines both for producing the necessary blast for the furnaces and for providing light and power to the works and surrounding district. This, in itself, forms a huge source of economy, and will no doubt, in the future, be universally applied.

We now come to a consideration of the gas itself. Producer-gas is understood, technically, to mean the gas generated by the partial combustion of carbon or carbonaceous matter, in a closed chamber called a "gas producer." In practice, the carbon is supplied in one of the numerous forms of coal, charcoal, or coke, while for certain purposes lignite or peat may be used. The quality of the fuel largely influences both the composition of the gas produced and the design of the producing plant itself. When air alone is supplied to the combustible the carbon simply burns to carbon monoxide and parts with some 5800 of its available 14,600 B.t.u. per pound, leaving the other 8,800 B.t.u. bound up in a convenient form for use in the engine cylinder. We thus use up 40 per cent of the heat lying dormant in the carbon with the object of storing up the residual 60 per cent in a convenient form for the direct production of mechanical energy. This seems at first sight to be a most uneconomical proceeding, but the waste of heat in other forms of transforming apparatus is so great as to justify this apparent waste. Of course, some of this sensible heat is recovered, as we shall see later on. The theoretical composition of the gas thus generated is some 35 per cent of carbon monoxide and 65 per cent of nitrogen, giving a calorific value of 118 B.t.u. per cubic foot. This is the theoretical composition of blast-furnace gas. The coke present in excessive quantities presents a deep bed of incandescent fuel to the air blast with the result that the furnace becomes a huge gas producer. The quality of the gas, as we have seen, is poor, but it is free from tarry matter, and when denuded of its dust forms an admirable fuel for the large double-acting engines chiefly met with in continental practice. The low explosion pressure given by this gas provides an indicator card very similar to that of the steam engine, with a corresponding absence of shock in the moving parts and a more uniform turning effort at the crank than is obtained with engines working on richer gases. Smaller producers, working on air blast, however, tend to clinker up, owing to the high temperature, and thus give intermittent working and bad gas. To absorb some of the 40 per cent of sensible heat given out by the carbon, steam is added to the air on its way to the producer. The reaction of steam with incandescent carbon is endothermic and results in the production of equal volumes of carbon monoxide and hydrogen. The resuling gas, called water gas, has a thermic value of about 350 B.t.u. per cubic foot. The addition of steam therefore has the double effect of reducing the temperature of the producer and enriching the gas produced, the normal calorific value of "semi-water gas," or producer gas proper, being about 160

* American Machinist.

B.t.u. per cubic foot, when bituminous coal is used as fuel. The great question, however, is "How much steam shall we use?" The Mond plant uses about 2½ pounds of steam per pound of coal consumed, while the blast furnace uses none. It is obvious that, with excess of steam, as well as with no steam at all, the conditions are not so favorable for the production of a rich gas, as they are at some intermediate stage. The combustion of carbon, even with a small supply of air, cannot always be limited to the production of carbon monoxide. The higher oxide, CO_2, is always present in large or small quantities. The extent to which the higher oxide is formed, is solely a function of the temperature, so that the admission of steam in controlling the temperature has a further action upon the chemical composition of the gas produced. A temperature of 1,000 degrees Centigrade and over, favors the formation of monoxide, while at lower temperatures the proportion of carbon dioxide in equilibrium with the monoxide becomes greater and greater as we approach 600 degrees Centigrade, below which the action becomes inefficient. For a rich gas and high efficiency the producer should therefore be kept as hot as is consistent with successful working and the non-formation of clinker.

The formation of carbon dioxide instead of carbon monoxide does not, however, in itself imply inefficient working, as the extra heat liberated by the complete combustion of carbon could, theoretically, be utilized for the decomposition of steam, or to raise steam for the process itself. At a low temperature, however, the bulk of the steam passes unchanged through the producer and is simply condensed in the scrubbers, so that the heat thus used would be entirely wasted. The experiments of Doctors Bone and Wheeler on a 2,000-horse-power Mond plant tend to show that no economy, but rather loss, attends the introduction of excessive amounts of steam into the plant. It was found that the best results were obtained with a feed of some 0.45 pound of steam per pound of coal consumed. This was with a large plant using bituminous fuel and regenerative apparatus. With a small producer using anthracite pea coal and no regeneration, my own results point to a supply of 0.7 pound of steam per pound of coal consumed as the best figure. This gave a gas very similar to that usually obtained in a suction plant, and, indeed, the conditions obtaining during the test were very similar to those under which suction plants work. The practice of adding 1 pound and upward of steam to the air blast is, therefore, wasteful in steam, necessitating the erection of a large and costly regenerative plant to recover the latent heat of the unchanged steam and produces a poor gas.

The fuels principally used in gas producers are anthracite and bituminous coals. The former, consisting of 90 to 95 per cent of carbon, produces very few volatile hydrocarbons and little ash and is, therefore, an admirable fuel for this work. On the other hand, it produces a poor gas, and on account of its scarcity in England is very costly. The bituminous coals are cheap and abundant, and can be used in plants of the largest size. It is noteworthy that these producers are designed to use the smallest sizes of coal that were formerly useless for steam-raising purposes, and to use the very cheapest fuel available. The chief objection to the use of bituminous fuel is due to the large quantities of volatile hydrocarbons given off by the coal on heating. The presence of these impurities necessitates the use of elaborate cleaning devices to wash out all the tar and dust from the gas before it enters the engine cylinder where these deposits form a prolific source of trouble. Even with the present-day washers, small quantities of tarry matter leak through the apparatus and necessitate the frequent cleaning of valves, or else preignition occurs. The initial cost and complication of this cleaning plant is sufficient to prohibit the use of bituminous coal in small installations where the cheap fuel would otherwise be very welcome. Consequently plants of small size are almost invariably worked with anthracite or coke. The latter, though cheap, contains invariably quantities of ash, which tend to fuse into clinker, so that its use is by no means so widespread as one would otherwise expect.

The design of the producer and plant depends almost entirely on the class of fuel used. A non-bituminous fuel is free from volatile matter, the producers and cleaning plant are very simple in design, simply consisting of a firebrick-lined shell with a grate supporting a deep bed of fuel and devices for feeding in the fuel and taking out the gas. The air is forced in by a steam injector when an auxiliary boiler is provided, or, if not, by a fan. Although the plant may be slightly less efficient when the injector is installed, yet it is more self-contained, as the presence of a fan presupposes the existence of an independent prime mover or a separate electric supply. The sensible heat of the hot gases, which leave the producer at a temperature of some 300 degrees Centigrade, are usually extracted by a boiler or regenerator surrounding the outlet pipe, or in the top of the producer. The only cleaning and cooling apparatus necessary is a coke scrubber and a sawdust drier. It is obvious that the gas must be cooled to as low a temperature as is economically possible so that the maximum weight of gas and air may be admitted to the engine cylinder. The high cost of the fuel forms a serious obstacle to the extended use of this type of plant. For some years after the introduction of gas producers, the engines used with them were quite small, and so it was quite possible to use these high-grade fuels. But of recent years the gas engine has been developed to give 1,000 to 4,000 horse-power in single units and the capacity of the producer has been correspondingly enlarged. When large quantities of fuel are daily being converted into combustible gas, the price of fuel becomes an important item. The utilization of our cheaper grades of coal, and even lignite and peat, has, therefore, assumed an important phase.

There is nothing new in making gas from bituminous coal—this has been done from the first for furnace work where the hydrocarbons present are actually advantageous, as they increase the heat of combustion of the gas. For engine work, however, the tar and soot must be effectually cleaned out of the gas, and it is here that the chief difficulty lies.

The first serious attempt to tackle this problem was made by Dr. Ludwig Mond, and the details of his famous plant are now well known; it is, therefore, unnecessary to describe it here.

It should be remembered, however, in connection with this part of the subject that bituminous coal contains a fair proportion of nitrogen which, under suitable conditions, appears in the gas in the form of ammonia. On treatment with sulphuric acid, one ton of coal yields something like 70 to 90 pounds of ammonium sulphate, which can be sold for agricultural purposes at a price of about $12 per long ton. This means that if coal dust or slack at 12 shillings per ton be used and a yield of 70 pounds of ammonia obtained, the return in by-products alone is about 60 per cent of the fuel bill.

This is an important item, and it is no wonder that attempts are made to keep the conditions such as will preserve this ammonia from decomposition. What are those conditions? The temperature inside the producer must be kept below 500 degrees Centigrade, whereas in the ordinary producer it is about 1,200 degrees Centigrade. This means, as we have seen before, that an excessive amount of steam has to be used to keep down the temperature, with a consequent deterioration in the quality of the gas. In fact the content of carbon dioxide in a normal Mond gas is about 16 to 18 per cent. The amount of steam used in the plant is about 2½ pounds per ton of coal, about five times as much as is needed to supply the best gas. As only about 20 per cent of the steam is decomposed in the producer, it follows that the free steam carried away by the gas, takes away from the producer an enormous amount of latent heat, with the natural consequence that the regenerative apparatus is both costly and cumbersome. On the other hand, it has been found that the sulphate cannot be profitably recovered with plants of less than 2,000 horse-power, so that for smaller sizes, it scarcely justifies its existence and should be replaced by a simpler and cheaper type of plant. The erection of towers filled with pipes for transferring the heat from water to air and *vice versa* is both costly and uneconomical. In a test of a 500-horse-power Mond plant it was found that the heat taken up by the air in the warming tower was only about 20 per cent. of that carried by the water. The gas should be split up into smaller sprays and the wetted surface presented to it be very much greater than is obtainable in these towers. The dashers used, too, are very deficient in this respect and are of a very weak form. The question facing the manufacturer who wishes to install gas producers for his engines is this—whether he will use his plant as an ammonia manufactory with gas as a sort of by-product or whether he will use a reasonable amount of steam in the producer and use it to the best advantage for producing a fairly rich gas suitable for engine work. The answer to this depends largely on local circumstances and no definite rule can be laid down to cover all cases. To return to the tar, it is found that however much the washing apparatus for these types may be multiplied, tar globules have a knack of worming their way through them and ultimately finding their way to the engine cylinder. Attempts have been made to split up the hydrocarbons by passing them through a hot zone inside the producer. This may be done by inverting the combustion so that the air is introduced above the fuel and blown downward through the incandescent fuel. It was effected in another way by Whitfield, who drew off the tarry vapors from the raw fuel by means of the steam injectors and introduced them into the hottest part of the fire. Other makers have a deep charging bell which forces the vapors to take a downward sweep before leaving the top of the fire. These complications make the working of the plant more difficult and considerably add to its first cost. The results obtained, moreover, are not commensurate with the extra trouble and expense, as the tar cannot be reduced in this way by more than 30 per cent. Most experts are of the opinion that the temperature of the producer is nowhere high enough to split up this tar, and that the so-called fixing is merely a burning to carbon dioxide with a consequent deterioration in the quality of the gas. In effect, gases obtained by this method usually contain more dioxide than when the tars are unfixed. It is generally considered therefore, that the simpler method of washing or condensing out the tar is preferable to that of destroying by heat. In this connection, atmospheric coolers are both bulky and expensive, besides being inefficient, although they dispense with the use of water. For extracting the tar, I am of the opinion that by far the most efficient apparatus is a fan, rotating in the gas at a very high speed. A water spray, introduced into the middle of the rotor, is broken up into extremely fine drops which seize the globules of tar and dash them against the casing, from which they drain into the settling tank. These fans are very efficient in practice; the power required to drive them is small, and their water consumption is low. For satisfactory cleaning it is advisable to send the gas through two fans in series. Owing to the complex nature of the fuel, it is only natural to expect that these bituminous producers and plants should be more troublesome and expensive than those designed for the simpler kinds of fuel. Both the first cost and the up-keep of the former type are greater than those of the non-bituminous variety and this increased expenditure forms an offset to the cheapness of the fuel. The use of gas from bituminous coal for engine work is, however, comparatively recent, and we may expect that after more experience has been gained in the working of this kind of plant the results, which are even now very creditable, will make the gas plant a still more formidable competitor with other sources of power.

PRODUCTION AND USES OF TUNGSTEN.

ONE of the most widely known of the rarer metals is tungsten. The production of this metal in the United States, however, is not large, as a little of it goes a long way for some of its most important uses. As by far the largest part of the tungsten produced is used in making tool steel, the demand for tungsten decreased greatly during the recent depression in the steel industry. In 1908 the domestic production of tungsten ore, reduced to an equivalent of ore carrying 60 per cent of tungstic trioxide (WO_3) the ordinary commercial basis in the United States, was 671 short tons, valued at $229,955, as against 1,640 tons, valued at $890,048, in 1907. The statistics at present available from foreign countries show a similar decline. These figures are taken from a report by F. L. Hess, of the United States Geological Survey, published in an advance chapter from "Mineral resources of the United States, calendar year 1908." Mr. Hess gives also details of the industry by States, notes on the occurrence and uses of tungsten, and a partial bibliography.

Tungsten is of wide occurrence, but the individual deposits can hardly be said to be large. As a rule they are "pockety"—that is, they occur in lenticular masses or small shoots. Many of those at the surface are quickly and easily mined, but it may then take all the profits derived from the first ore body to locate another one.

The tungsten minerals used as ores are hübnerite, a tungstate of manganese; wolframite, a tungstate of manganese and iron; ferberite, a tungstate of iron; and scheelite, a tungstate of calcium. They generally occur in veins cutting igneous rocks that contain much silica, such as granite and granodiorite. Some simple tests for identifying these minerals are described.

The most important use of tungsten is as an alloy for tool steel, to which it imparts the property of holding temper at a much higher temperature than high-carbon steels. When lathe tools are made of tungsten steel the lathe may be speeded up until the chips leaving the tool are so hot that they turn blue. It is said that about five times as much work can be done by a lathe built for such speeds and work and fitted with tungsten-steel tools as can be done by the same lathe with carbon-steel tools. From 16 to 20 per cent of tungsten is ordinarily used in lathe tools.

There has been a widespread belief that most of the tungsten mined went into armor plate, but it is stated by the Ordnance Bureau of the Navy Department that tungsten is not now and, so far as known to that bureau, never has been used in the manufacture of armor plate in this country, and it is not known to have been so used in other countries, though it has probably been used in experimental armor plates. One of the most essential properties of armor plate is

its ability to resist shock, and this property is not imparted to steel by tungsten.

As the melting point of tungsten is very high—about 3,080 deg. C.—the metal is valuable for use as a filament in incandescent electric lamps, and such lamps are rapidly coming into common use. The whiteness of the light given by the tungsten filament makes it much superior to that of carbon and the efficiency of the tungsten lamp is more than twice as great as that of the carbon lamp. Thousands of filaments can be made from a pound of tungsten.

Tungsten salts are used in fireproofing cloth for curtains, draperies, etc.; in weighting silks; in glass making; as a mordant in dyeing; and for many other similar purposes.

HOISTING ENGINES AND BOILER PARTS.

THEIR PROPER DESIGNATIONS.

THERE is often a confusion of ideas as to the proper term to use when referring to any part of engineering apparatus, because a thorough knowledge of the machine is lacking. Often a false term is coined to designate some part, because the true name is not known, different engineers coining different names for the same part.

This applies to hoisting engines among other apparatus, and to assist the reader to know the correct terms to apply to the various parts of a hoisting engine and the boiler the accompanying illustrations of a Lidgerwood hoisting engine of the double-drum type are presented.

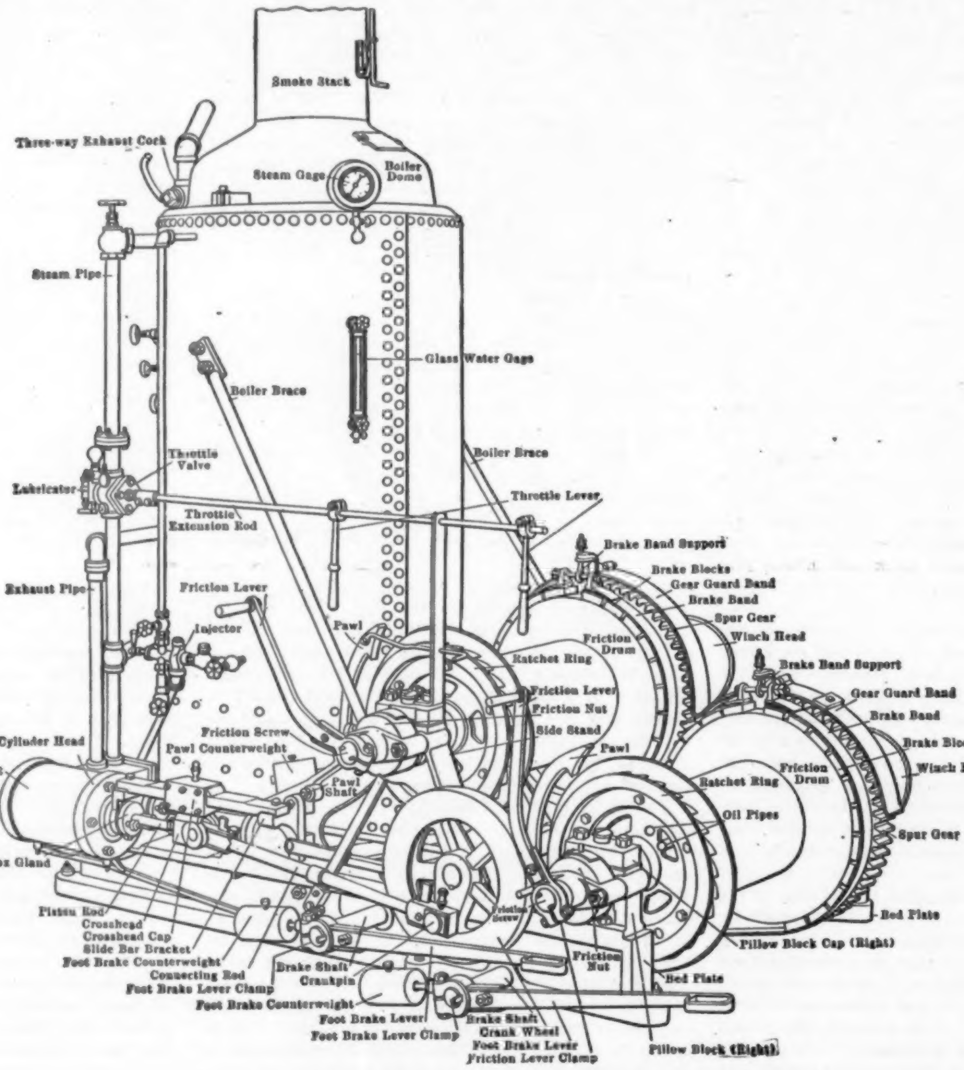


FIG. 1.—NAMES OF BOILER AND ENGINE PARTS.

In Fig. 1 are shown the engine and boiler complete, with all visible parts designated by their proper names. Figs. 2 and 3 show more of the parts in detail. In order that a new part may be secured from the maker of any type of hoisting engine, the engineer should familiarize himself with the correct names, and then there will be no delay in getting the order filled, instead of having to write several times.

Generally manufacturers have a printed list and the names of the parts are designated by numbers so that when a new piece is required, all that is necessary is to write for the number corresponding to the name of the part wanted.—Power and the Engineer.

Arrangements have been completed whereby a standard clock at the Hamburg Observatory, Bergedorf, is connected to the trunk telephone system. A sounder automatically emits a siren-like note from the fifty-fifth to the sixtieth second of each minute—mid-European time—and this goes automatically to all the receivers connected at that time with the special exchange number which has been allotted to the time signal. Thus Hamburg and neighborhood and other towns of east Germany are supplied with a ready means of ascertaining the standard time.

BRONZE FINISHING BY MEANS OF THE BRUSH.

L. MÜLLER, in his "Bronzewaren-Fabrikation" makes these observations with regard to the bronzing of metals by brushing on:

A good linseed oil varnish is essential. If the object is to have a gold-bronze finish, rub up a little ocher as fine as possible on a grinding stone, with the varnish, adding black and blue until the color looks a dirty green. Apply this to the object in two or three coatings, with a soft bristle brush. The first two coatings must be thoroughly dry before a third is put on; the last one is to be coated, when but partially dry, with the bronze powder, applied with a fine hair-brush. The hollows or depressions in the surface of the object are not to be covered with the bronze powder. When the last coating of varnish is dry, the superfluous bronze is removed with a stiff brush. Instead of the ocher for coloring dark green, cinnabar may be used. Gold-bronze is the natural color brought out upon brass and bronze by dipping or pickling, and it is then coated with a metal varnish, gold varnish or lacquer. Gold varnish is the chief factor in gold-bronze, being the only means by which a beautiful and brilliant color is obtained.

Iron, zinc, tin and lead are given a gold-bronze finish by application of varnish paint and subsequent coating or dusting over with leaf-gold, mosaic gold, or gold-bronze powder. If cast iron objects are heated until they blacken, and brushed vigorously, while hot, with a brass or copper scratch-brush, enough of the copper or brass will quickly be brushed upon them to give them the appearance of the latter metals, thus producing a red or yellow bronze. Brush until the objects have cooled to hissing heat; if the brushing were to be longer continued, the color would be brushed off again. The application of a good bronze lacquer will give a soft luster and the objects will be hardly distinguishable from real bronze. The raised parts will be bright and the depressions dark.

For a silver bronze finish, apply to the object two or three coats of white lead, rubbed up in varnish as above, and made silver gray (not too pale) by the addition of lamp-black, also rubbed up fine. The same rules are to be observed for drying as in the case of gold bronze. When the last coat is not quite dry, apply the silver bronze to the raised portions, proceeding exactly as in gold bronzing, the hollows of the object not being touched. Silver bronze is often used for parts of objects in contrast to gold bronze on other parts. Silver bronze can also be produced by coating the object with a lacquer or varnish paint and immediately applying mosaic silver or silver bronze powder, as described above in regard to gold bronze.

Copper Bronze—To copper-bronze iron and zinc, coat the objects first with a brown varnish paint and when this is nearly dry, apply copper bronze powder as in other cases. Copper bronze powder can also be mixed with spirit varnish and the two put on together.

The brown, copper-like bronze for zinc objects consists of spirit lacquer, with which is mixed a color rubbed up in alcohol. The objects must first be made perfectly bright and clean. Brushing and scratch-brushing with a fine copper brush will produce a red-

dish coating, which is to be varnished over with a thin, colored spirit lacquer.

Red bronze is produced by red bronze lacquer, red bronze powder or red mosaic gold. Before applying red bronze lacquer, the objects must be made bright

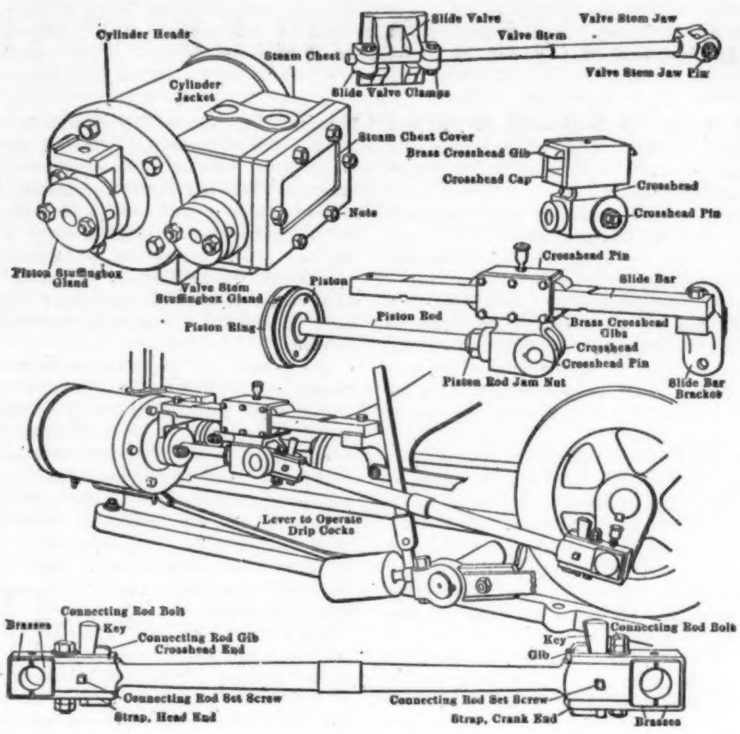


FIG. 2.—PARTS OF ENGINE.

and clean, as every spot will show through. Warm them, and put on the lacquer with a brush. If metallic bronze is to be used, coat the object first with a lacquer or varnish color, and when this is nearly dry, dust on the bronze with a piece of velvet or a soft brush.

Green bronze can be produced on tin, zinc and lead by means of a green, dead-luster bronze lacquer, or a green varnish color. Frankfort black and chrome yellow make the best mixture for the color. Most bronzings for cast iron are lacquer or varnish mixtures, but they must not be too lustrous, or the object will not look like metal; only a soft, subdued luster has the appearance of genuineness.

Sheet metal objects are also bronzed by first lacquering them, and when the lacquer color is dry, applying metallic bronze, red, yellow, gold, white or silver by wiping it on. Before lacquering, the objects must be rubbed with powdered pumice stone, ashes or hartshorn. Fine articles should be polished after each application of the varnish, except in some cases the last. If there are figures, flowers or other decorations the final polishing is not to be done until after the painting has been varnished. Sheet metal objects are usually coated with a light colored transparent varnish after the bronzing is finished.

For small objects of cast zinc, only the best and oiliest lacquers must be used, otherwise they would soon be spoiled by the action of water. If such objects have been cast in sand molds, they must be well chased. In the case of large objects of cast zinc, such as chandeliers, etc., chasing is not necessary, provided the casting was successful, as the lacquer will conceal many rough or imperfect places. The lacquer colors for cast zinc objects of monumental size must not be too brilliant, but should have a dull, quiet tone; the luster can indeed be subdued by rubbing on metallic bronze, but the effect is more beautiful where this has not been done.

Bronzing by the application of lacquer colors requires, first of all, practice, also taste and a sense of beauty, to guide in the selection of the right tones. There are different shades of all the colors, and the workman must have good judgment in choosing them to suit the object to which they are applied. With metallic gold, red, or silver, the beauty of the effect will lie in the contrast of the darker colors of the hollows and the lighter bronze of the raised portions; and it is essential that the bronzer should know how to produce a gradual transition from light to dark, and how to make the shading appear natural. There are no rules for this; artistic perception is often the only guide, and experience is the best teacher. Hartmann says that metals can be most finely bronzed when perfectly bright and clean, and that by skillful application of the bronze with a soft brush, and rubbing it in, the luster can be varied in different portions of the bronzed surface, as its nature may demand. It is also recommended to rub the surface lightly with linseed oil before applying the bronze. It is certainly true that the bronze will adhere more easily and firmly to the oiled surface than to clean metals, but on the other hand, the fatty acids contained in the oil will act upon the bronze coating, which will, in consequence, soon lose its luster and become green by the formation of copper oleate.

Another method is to smear the objects with a highly diluted solution of paraffine in gasoline, and let this coating dry. The very thin layer of paraffine which remains on the metallic surface has a similar effect to that of the oil in helping to make the bronze powder adhere, but with this difference, that it does not act upon it chemically.

Mosaic gold is to be mixed with 4 parts of washed chalk to 1 part of gold, and applied to the copper or brass object with a moistened wad of linen; the metal will take on the appearance of gold, and the coating can be protected by a good elastic lacquer.

Iron objects are first to be coated with green cinnabar and powdered over, when the coating of cinnabar is dry, with mosaic gold, using a large, soft hair-brush.

RIVER GAGINGS.

The river gagings conducted by the United States Geological Survey are again threatened with complete abolition, for the sundry civil appropriation bill recently reported to the House contains no appropriation whatever for the work. The value of these gagings is so great in connection with irrigation, power, flood prevention and water supply enterprises that the continuation of the work is very desirable. A break of a year or more in the records of stream flow would be particularly unfortunate, for it is only by a study of consecutive gagings covering many years that safe estimates for great engineering undertakings can be prepared. Every engineer acquainted with irrigation and power works can cite cases where large sums of money have been wasted on account of insufficient information regarding the seasonal and annual fluctuations in the discharge of rivers. Now that it seems likely that those who receive federal grants for water rights of one sort or another will be required to compensate the government for these privileges, there is still further need for carrying on the gagings. The remarkably low cost of the gagings, the excellent organization for doing the work, which has been developed only after years of experience in selecting and training the observers, and the general willingness to assist in furnishing data evinced by engineers and riparian proprietors would be largely undermined by a failure to make the necessary appropriations for even a year. The same fate threatens the fuel testing and structural materials testing conducted by the Geological Survey, for the appropriations in the bill for such investigations are so small as to be wholly inadequate for any real progress. The National Advisory Board on Fuels and Materials is practically abolished by the bill, for it contains no appropriations whatever for its expenses. Its members have never received any compensation for their services, but their traveling expenses have heretofore been paid. In view of the great value and extraordinarily low cost of the work done by the hydrologic and technologic branches of the Geological Survey, it is to be hoped that Congress will not curtail it in the manner proposed by the bill.—Engineering Record.

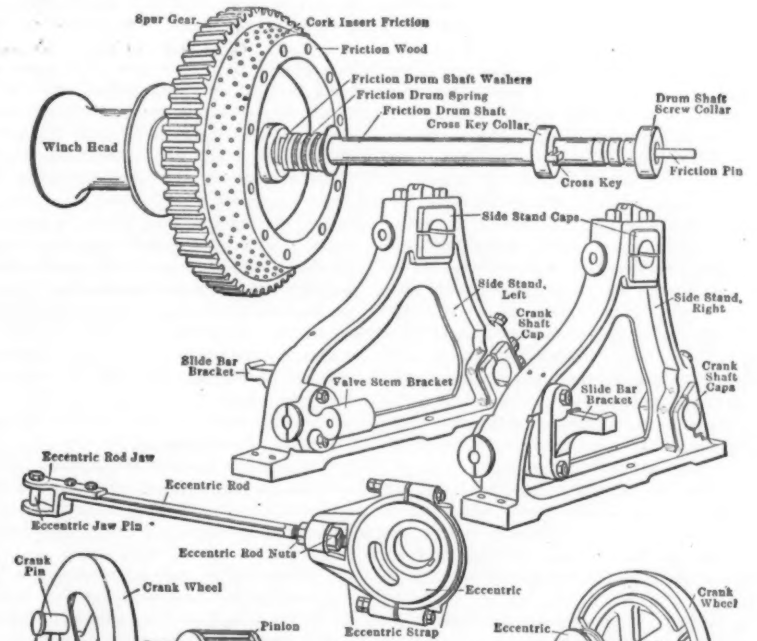


FIG. 3.—PARTS OF CRANK AND DRUM SHAFTS AND FITTINGS.

ILLUMINATING ENGINEERING.

ITS GUIDING PRINCIPLES.

BY PROF. SILVANUS P. THOMPSON.

For practically a century only have there been any systematic means of illumination in use in any civilized country. Before the year 1800 there were as means of illumination daylight, oil lamps, rush lights, tallow dips, and wax candles. Monarch and peasant, merchant prince and workman, had alike to depend on individual sources of light at night. Only in the larger towns and cities was there any organized attempt to light the streets by oil lamps. In 1819 the authorities of the day stoutly resisted the proposal to light the then House of Commons by gas—nothing but wax candles could be admitted; but gas lighting was coming in, and Argand and colza oil lamps were the sole competitors until after 1850. Everything else dates since then—practically during the last half century. For kerosene lamps were not widely spread until the sixties. Arc lighting, though tried for spectacular and lighthouse purposes from the fifties, did not come into public question until about 1879. Glow lamps followed three or four years later. Still later came incandescent gas mantles and acetylene gas lights, while the newest things in both gas lighting and electric lighting are affairs of only a year or two ago. Many persons now realize the immense stride made in the introduction of the Auer (Welsbach) mantle for incandescent gas; very many fewer people realize the significance of the corresponding step forward that has been begun by the introduction of the metallic filament glow lamp. We are on both sides in the very middle of an immense evolution in the art of illumination.

But while the means of illumination have thus been developing with amazing strides during a single generation, and the organized systems of distribution by municipal and urban and rural authorities, and by private corporations, have ramified throughout the community and brought supplies of gas and of electricity—shall I also say of oil?—to our doors, there has been another and very different development going on. I refer to the growth of that branch of the science of optics which deals with the measurement of luminous values. Photometry has been growing into an exact science by the explanation of its laws and the improvement of the instruments of measurement. It was not until 1760 that the first real discussion of photometric principles was made known. In that year Lambert, in his "Photometria," laid down the fundamental laws, and likewise in the same year Bonguer gave to the world his "Traité d'Optique," wherein a primitive photometer was described. Rumford's shadow photometer was invented in 1794, and Ritchie's in 1824. Then comes a long gap. Save for Bunsen's over-rated grease-spot instrument, there was no important advance in photometry until the eighties, when there were produced many novel forms, some of them including the now well-known forms of L. Weber, Lummer-Brodhun, and Rood, capable of yielding results of much higher precision in the comparison of different sources of light. Also in the eighties we meet for the first time with special forms of photometer of the kind destined to play a very important part in the work of our society, many photometers measuring the values, not of the brilliancy of a source of light, but the illumination of a surface.

Our primary concern is the adequate and proper illumination of things; and as we have to reduce the present chaos to an exact science, our first business is to secure some common agreement as to the measurement of illumination and the establishment of reasonable rules as to the amounts of illumination required in different cases.

Foremost, then, in the programme of work for our society we put the question of the units of measurements and the promulgation of the proper definitions of them. We must secure agreement—national and, if possible, international—as to what shall be taken as the unit of light and what as the unit of illumination at a surface.

Happily, the long-standing controversy as to the former appears to be settling itself by at least a preliminary agreement between the standardizing laboratories of the great nations. One "candle" is no longer to be a vague and indefinite thing. The new definition provisionally agreed upon is an ideal unit, in terms of which one can describe the several standards in use in different countries. If this provisional *entente* can but be ratified by a little international common sense we shall have henceforward an international "candle" such that it is the same in England as in America, equal to the *bougie décimale* accepted in France and related to the Hefner candle of Germany in the precise proportion of ten to nine.

But we have still to find agreement on the standard of illumination. Here in England, and in the United States, we have already grown accustomed to describe amounts of illumination of surfaces in terms of a British unit—the "candle-foot"—not perhaps a very happy term, one that we would readily exchange for a better—meaning, thereby, the intensity of illumination at a surface situated at the distance of one foot from a light of one "candle." The source being assumed here to be concentrated at a point, the law of inverse squares holds good.

Adopting the candle-foot as the unit of illumination, one may readily state certain facts with definiteness. All competent authorities are agreed that at night, for the purpose of reading, an illumination is required not less than one candle-foot, some authorities saying 1½ candle-foot. The facts appear to be that reading is impossible with an illumination of one-tenth candle-foot, difficult and fatiguing with one of one-fifth candle-foot, comfortable with from 1½ to 3 or 4 candle-foot, but that if the illumination exceeds 6 or 8 candle-foot, the glare of the page is again fatiguing and dazzling. The page should neither be under-illuminated nor over-illuminated. Something depends, it is true, on the size of the print. Under a feeble illumination of, say, ½ candle-foot, a type of pica size printed in a fount of bold face properly inked is legible when one of long primer size, printed in a weak way, would be practically illegible. Something also depends on the state of the eye as affected by the general illumination of the surroundings. Very seldom does one find in any ordinary room an artificial illumination exceeding 3 candle-foot. By day, on a writing table placed near a north window—or near any window not receiving direct sunlight—the illumination may exceed 3, and may even attain 4 or 5 candle-foot.

Until a unit of illumination was thus agreed upon, it was impossible to render any reasonable certainty to estimates of the amount of illumination in any case of dispute. What is the meaning of the term well-lit as applied to any room, building, factory, workshop, or school? Formerly the term was entirely vague. To-day the answer can be given in numerical terms. Formerly judgment had to be made by the unaided eye, and the eye is notoriously a bad judge. As between two different illuminations, the powers of discrimination of the eye are very limited. The eye can equate, but it cannot appraise. It can tell with fair accuracy whether two adjacent patches are equally bright. If they are not equally bright it cannot say with any kind of proportionality what their relative brightnesses are. All photometry depends on the perception of an equality.

Photometers for the measurement of illumination have been mentioned earlier as coming first into notice in the 'eighties. One of the earliest in this country was that constructed by Sir William Preece, with the assistance of Mr. A. P. Trotter, for measurement of the illumination of sidewalks and pavements of streets. It has been subsequently developed by Mr. Trotter, and as constructed by Mr. Edgcombe is a most useful and handy instrument, telling the amount of illumination directly in terms of the candle-foot. Another, by Mr. Haydn Harrison, measures the illumination, not on the horizontal, but at 45 deg. Almost equally early with the Preece-Trotter illumination photometer was the school photometer of Petruschewsky, apparently little known in this country. Most recent of this sort is the form due to Martens.

The principles and construction of photometers are matters that have interested me for nearly thirty years. About 1880 I brought out a form of wedge-photometer (modified from Ritchie's form), in conjunction with Mr. C. C. Starling, for electric light measurements. Later I gave to the Physical Society an investigation of the errors arising in photometry from the almost universal assumption that the law of inverse squares is fulfilled. In 1882, when lecturing at the Crystal Palace Exhibition, I gave diagrams to show the effect of the superposition of illumination from two or more lamps, and discussed the variations of illumination in a street between the places of maximum and the places of minimum illumination. Twelve years ago I described a tangent photometer, which has remained a mere optical curiosity.

No one can have worked at the photometry of modern lamps, or of the illumination of surfaces lit by lamps, without becoming conscious how much misunderstanding there is of the elementary laws of illumination. There is Lambert's cosine law, admirable and simple if only it were not in so many cases vitiated by the presence of organized—that is, specular—reflection. There is the law of inverse squares, itself a universal geometrical law of action radiating from a point, so fatally and absolutely misleading if applied to any other case than that of action from a point.

One subject on which more information is badly needed is the specific brightness of surfaces of different kinds when subjected to a standard illumination. For instance, how much light is reflected, per square inch, when illuminated with an intensity of 1 candle-foot, from such materials as oak panelling, whitewash, brown paper, or the surface of a red brick wall? Here in this theater the walls are tinted of a dark Pompeian red or maroon, which reflects but little light. The extra annual expense of lighting that might be saved had a lighter tint been used is surely worth considering.

The subject of diffuse reflection which here comes into play has indeed been investigated partially by several persons. There are Dr. Sumpner's researches of 1894 and those of Mr. Trotter on white cardboard and other white matt surfaces, but how few others! Again, there is the subject of diffuse refraction, which occurs in ground-glass shades, ribbed and corrugated glass panes, and other devices for diffusing the concentrated light of lamps. Yet how little does any optical book tell us on the subject of diffuse refraction. Reflection and refraction as they occur at dull or irregular surfaces appear to be of no importance to the academic writer of text-books of optics, but they are of vital interest to the illuminating engineer. Again, there are a number of semi-physiological problems that demand investigation and settlement. We all know that our eyes have an automatic diaphragm which stops down the entering light to protect our eyes from glare, rendering us relatively insensitive to bright lights. Does anyone know whether the contraction of the pupil depends on the total amount of light entering the eye or on the intensity of the image on local patches of the retina?

Again, we all know how an unshaded arc lamp, or even glow lamp, "cuts" the eyes by the very concentration of its beams, even when it may be many feet away, while the same actual amount of light, if diffused over a greater apparent surface, as by a surrounding globe of ground glass, is quite readily endured, and does not produce the same painful sensation. Does anyone know how great is the specific brightness of surface that the eye will tolerate without experiencing this discomfort? We can look at a white cloud or at the blue sky without pain. Can we endure a specific brightness of so much as one-tenth of a candle per square inch?

Our eyes are provided by nature with a most exquisite and automatic iris diaphragm which opens in the dark and closes in the light, thereby shielding us partially against the evil effects of glare. Putting it in the language which the photographer uses to describe the stopping-down of a camera lens, the automatic iris of our eye can close the pupil so that while in a comparative darkness the aperture opens to $f/2$ or $f/2.5$, it closes, amid a brilliant surrounding illumination, to about $f/20$. Suppose we are looking out in relative darkness, and are confronted with a brilliant patch shining with a specific brightness of one-tenth of a candle per square inch, we shall feel a certain amount of discomfort from its glare, and if we regard it steadily for a second or two will, on closing our eyes or turning away, see those persistent colored images that trouble us after looking at any very bright light; but now let the same brilliant patch be placed against a bright background. Far more light will enter the eye; the automatic iris of the eye will in a few moments have contracted, stopping down the lens of the eye so that it will be far less sensitive. In these circumstances will the patch that has a specific brightness of one-tenth candle per square inch pain or dazzle the eye? I ask the question, but I do not know the answer. Does anyone know what the answer ought to be? It is a simple question, and a few experiments would soon settle it. Of course, one must admit that the automatic action of the iris diaphragm, important as it is, does not by any means account for the whole of the facts about the want of proportion between the intensity of a stimulation and the in-

* Abridged from the inaugural address delivered at the inaugural meeting of the Illuminating Engineering Society.

tensity of the resulting sensation. Fechner's logarithmic law of psychophysics gives a clue, but even this does not seem capable of expressing, much less of explaining, the facts about the observed want of proportionality. Why should a light of ten-fold brilliancy not produce a sensation ten times as intense? And why should a greater brightness of the general surroundings relieve us of the annoyance of those colored after-images? After-images can be seen even under extremely feeble illumination, as I have again and again found. Has anyone discovered any exact law governing their occurrence?

All these queries show that there is plenty of work awaiting us, even in the mere collection and completion of such scattered information as is already available; but there are even more important questions before us, more important, not in science, but in their relation to the public welfare and the economics of the community.

Now that we have a standard of illumination and simple portable instruments that will measure it, there can be no excuse for inaction or ignorance in applying that knowledge to securing proper illumination for public and private buildings.

Let me begin with school buildings. They are the most important; for whatever bad results flow from bad lighting of churches, factories, or railway stations, those which result from the bad illumination of schools are far more to be deplored—they imperil the eyesight of the next generation.

All ophthalmic surgeons agree that the cause which forces the children into increasing shortsightedness is protracted poring over books under an insufficient illumination. Even in what an inspector might call a well-lit school the illumination at the surface of the desk may be quite insufficient if the desks are badly placed, or the windows insufficiently high, or the lamps badly distributed.

All educational authorities ought henceforth to insist on rational requirements as to lighting. Hitherto they have had nothing definite to specify; now that illumination photometers are available, they ought to require a minimum of 1½ candle-foot at the worst lighted seat in the schoolroom, and not depend on purely architectural rules about heights of windows or areas of window space. In England the Board of Education, in its Building Regulation (1907), Rule 6, clause c, has laid down a foolish rule: "Skylights are objectionable. They cannot be approved in schoolrooms or class rooms." That perfectly monstrous provision ought to be at once repealed. The universal experience of the textile industries, where adequate lighting of spinning and weaving machinery is a prime necessity, is that no method of lighting is so satisfactory as skylights in roofs specially constructed to receive light from the northern sky.

Hitherto little attention has been paid by either local or central authorities to conditions affecting the lighting of factories and workshops. It is true that the factory inspectors require periodic whitewashing of factories, but that is for sanitary reasons, not primarily to secure better illumination. The Home Office has its regulations as to temperature and degree of moisture required or permissible in the different classes of factories and workshops. Then why not also similar regulations as to the proper amount of illumination? Surely the eyesight of the workers is as well worth protecting from injury as their lungs and their limbs. So far as I am aware, Holland is the only country in which legislation has fixed a statutory amount of illumination in factories, the figure there being from 10 to 15 candle-meter, equivalent, therefore, broadly to the value of 0.9 to 1.35 candle-foot.

Architects are often blamed for deficiencies in the lighting of the buildings they design, perhaps more often for the deficiencies found at night by artificial lighting than for those of the lighting by day. For this the fault rests no doubt largely with the persons who has installed the lighting arrangements, and one must not blame the architect too severely for having been as ignorant as all the rest of the world about the principles of illumination; but herceforward, when once it is known how much illumination is required in the rooms of different kinds, the architect ought in his specifications to set down, with appropriate numerical values, what degree of illumination is required in the various parts of his building.

I venture to suggest that it would be a good thing if some committee could draw up a model specification, or model clauses for architects to insert in their specifications, in which the proper way of prescribing the requisite amounts of illumination in different classes of cases should be set forth.

THE ELECTRIC LIGHT IN MEDICINE.*

DIFFERENTIAL INDICATIONS FOR ITS USE.

BY A. D. ROCKWELL, M.D.

THERE is no more important and efficient method in its relation to therapeutics than the application of light and heat, and although much has been written about it, and much use has been made of it, yet, from the standpoint of those who from personal experience fully appreciate its value, it seems surprising that there is not a more universal recognition of its varied therapeutic properties.

In the few remarks that follow on light therapy it is not my thought to include the whole of phototherapy. I do not propose to discuss the Finsen light, which is a very important part of phototherapy, but for the information of those who have a confused idea of what constitutes the Finsen light, and imagine that it is a very simple and easy thing to get, a word may fitly be said. The Finsen light, whether derived from sunlight or the electric arc light, exerts only actinic or chemical effects. In Finsen's original installation, an arc light of 20,000 candle power was used, and the intense heat thus developed had to be absorbed by an elaborate cooling process before the ultraviolet rays were available for practical and efficient use. The original Finsen lamp required 80 amperes of current and 60 minutes of exposure, but with simplified apparatus good work can be done with five amperes and less exposure. Strictly speaking, the essence of the Finsen light is not light at all, for the ultraviolet frequencies of infinite rapidity are no more visible than the still higher frequencies of the X-ray, or the far lower frequencies that we appreciate as sound or heat. The effect of the so-called Finsen light then is local and superficial, of remarkable value, in the treatment of skin affections, but of little worth in deep seated morbid conditions.

The ultraviolet ray has no power of penetration. It is immediately absorbed by the blood, and even when the parts are rendered anemic by pressure or by adrenalin and cataphoric action, its penetration is still comparatively superficial. Used alone and uncombined it exerts no general constitutional effect, and acts only on the periphery, but as Finsen demonstrated is invaluable in dermatological cases, and especially in the treatment of lupus. It cannot be too often repeated that the difference in forms of physical energy is one of degree rather than of kind. The three things that go to make up a complete light treatment, or phototherapy, are the heat, light, and chemical rays which are simply different rates of vibration. Sound, which is a lower rate of vibration, we do not regard of therapeutic value, but as vibrations increase in frequency and decrease in length we get the heat rays, then light (the visible spectrum) until finally we enter the region of the invisible (the ultraviolet), and beyond this the X-ray. Light, heat, and chemical energy constitute the trinity of phototherapy. These combined effects are undoubtedly represented best by the rays of the sun—which when concentrated act more powerfully than those from any artificial source, but for obvious reasons their general and successful utilization is impracticable.

The two available artificial sources of this method of treatment are the incandescent lamp and the arc light, either of which are superior both in physiological and therapeutic effect to the ordinary hot air bath, for the reason that the latter is more depressing and far less penetrating than radiant heat, and is without chemical activity. In the administration of light energy, one should bear in mind an important fundamental principle, viz., that resistance develops energy, a principle as striking on its moral and intellectual side as on its physical. Electricity, for example, is of value therapeutically only as it meets with resistance, and in the same way, light cures disease only as it meets the resistance of the human body, and is transformed into radiant energy. The rays from a powerful incandescent or arc lamp readily penetrate the skin, but in overcoming the deeper and denser structures are converted into heat. Heat, therefore, is one of the principal therapeutic factors in the use of the electric light.

It may be observed further that radiated heat, as developed by the incandescent, and especially by the arc light, results in a more rapid and powerful dilatation of the superficial vessels than the action of simple hot air, and this relaxation of vessels, because of no appreciable heating of the surrounding air, can be continued indefinitely. These light rays exert a remarkable stimulating effect upon the peripheral nerve endings, and may be utilized to excite perspiration more quickly than any other method. The superior efficiency of this form of radiant energy is increasing oxidation, and tissue changes are evidenced by the elimination of carbon dioxide. As indicated by this elimination, oxidation goes on far more rapidly under the influence of radiant light than of simple hot air. Another well recognized and important factor in the light treatment, more especially the arc light, is its action on the blood. The hemoglobin carrying power of the red corpuscles is demonstrably increased, and through the influence of its invisible rays upon micro-organisms we get pronounced bactericidal effects.

My first experiences along this line were with the incandescent lamp, not the ordinary incandescent light bath, made up of many small electric bulbs inclosing the body of the patient, but of a single lamp of 500 candle power.

Placed within a cylindrical metal hood and suspended by a convenient mechanism, the light can be easily applied to any and all parts of the body. For the relief of pain and especially in the treatment of neuritis it is invaluable.* I even went so far as to say that in the relief of local painful conditions and in its general constitutional influence it was superior to the arc light. In this I believe I was mistaken. After a more extended experience in its use I do not hesitate to assert, that while the arc is quite as valuable as the incandescent light for the relief of pain, its influence upon defective blood and skin conditions is far superior. From what has already been said as to the composition of these two manifestations of light, it is not difficult to understand why this may be so. Both are forms of radiant energy, but in the incandescent or leucodescent lamp the glass globe effectually intercepts the chemical rays, while the arc light with no intercepting barrier gives the full value of the concentrated solar ray. While, therefore, theoretically, it is no difficult matter to decide upon the relative value of these two forms of light and to rule as to some differential indications for their use, practically it has not been quite so easy. Many cases had to be treated, some by one method, some by the other, with results on the whole seeming to indicate the greater efficiency of the arc light, but it was not until the two methods were successively used in the treatment of the same patients that the superiority of the one method to the other became strikingly manifest.

Briefly stated, the superiority of the arc light to the incandescent in the treatment of certain local surface conditions, and conditions constitutional and general is due to the fact that with light and heat are combined the subtle chemical reactions which are wanting in the other. The arc light represents all the rays of the spectrum as does the sun itself, and practically it is nothing but sunlight. Fortunately, however, for our therapeutic purposes, it is far more controllable than sunlight, and can instantly be made intense or mild, concentrated or diffused, and even the different light rays selected or excluded at will.

* Medical Record.

* See article on "Phototherapy in Neuritis," Medical Record, November 9th, 1907.

Soldering ordinary platinum vessels is commonly done with platinum itself as the soldering material or with pure gold, using the oxyhydrogen blow-pipe or its equivalent melting flame. Gold has the disadvantage that it melts at a lower temperature than the platinum, and under temperatures to which crucibles or other vessels may be subjected it melts and leaves the crack open. In Central-Zeitung für Optik und Mechanik it is recommended to close the crack with a mixture of platinum powder and turpentine oil, then to heat the joint to a white glow, and in this condition to hammer the parts together. Another method, applicable where the crack is on the edge, consists in hanging a narrow strip of platinum sheet over the crack, then placing the article in the fire, heating it white hot, and hammering if necessary. According to Metall-Arbeiter a small hole may be closed by a rivet made of platinum wire, welded after hammering both heads closely. For larger holes a patch is made of platinum sheet.

CARTAGENA: "THE HEROIC CITY."*

A TOWN WITH A MELODRAMATIC HISTORY.

BY ISAAC A. MANNING.

"Cartagena de Indias," as it was termed by the ancient governments, on the north coast of the republic of Colombia, now spoken of in Colombia as the "Heroic City," has more of the tragic and melodramatic in her history perhaps than any other city on the western continent. The stage settings about which the many events took place are to be seen yet, arranged to the various effects in the tragedies and dramas which occurred in the earlier periods of its existence.

LOZANO STREET: A TYPICAL STREET IN CARTAGENA.

Older than any city of America and the new world except Santo Domingo and Mexico, and founded by virtue of royal decree which declared it a "very royal and loyal city," it has retained more of its early characteristics, perhaps, than all the others. The medieval flavor surrounds it. Its antiquity is everywhere in evidence, and the air of romance hangs over it. One feels it, sees it, hears it at every step within its old, battlemented walls.

When Bastides first took refuge within its harbor in 1501 he declared it the natural point for a city, and Pedro de Heredia, who was to govern it through many vicissitudes, and finally die in shipwreck on the shore of his native land, whither he had gone to answer charges of his enemies, was given the first warrant as Governor of Cartagena. He established the city in 1533, and the following year the King of Spain sent there a bishop of the church. From that time to the end of Spanish rule no place on the Spanish Main suffered more changes from prosperity to adversity, and *vice versa*.

A PART OF THE WALL SURROUNDING CARTAGENA.

CARTAGENA: "THE HEROIC CITY."

Here came the gold of the Perus for shipment to Spain, and, as the capital, it was the center of attraction for all sorts of adventurers. The frequent visits of pirates and buccaneers led the King of Spain to authorize the wonderful series of defensive works which encompass the town and harbor and which stand to-day as monuments to the constructive skill and engineering craft of the old Spaniards. The ramparts, battlements and general series of fortifications are so constructed that they are declared faultless from the view point of military engineers. They are all remarkably well preserved and are unique, in that their counterparts are not to be seen anywhere else in the new world. Built of coral stones, many of them so huge in size one wonders how they were handled, they are laid in a concrete, the mixture of which seems to be an entirely lost art. This is proven through efforts of the modern workmen to repair breaks in walks and walls, which repairs show no such strength as the old works of centuries ago.

Here came, before these muniments and donjons were built, such jolly visitors as Robert Vaal, Martin

* Bulletin of the International Union of American Republics.

Cote, Sir Francis Drake, the Sieur de Pointes, Du Casse, and other rovers, each being remembered by what he took away rather than by what he left; and the scenes of their exploits are pointed out. Among others, at the old convent of Santa Candelaria, on the top of the hill called "La Popa," lying back of the town, and which serves as a landmark to mariners passing that way, the white or light yellow buildings being visible for many miles at sea, one is shown where one of these gentlemanly fellows, in the spirit of pleasantry which so frequently manifested itself among them, is said to have hurled the nuns, who then held solitary worship there, over the edge of the perpendicular cliff on which the monastery and convent stood.

This old convent, one of the points which would first attract the curious attention of the tourist, was founded in 1608, and in the story of its foundation, it is said, the Holy Virgin appeared to Friar Alonzo de la Cruz Paredes, then at Bogota, ordering him to go at once to Cartagena and there erect a convent on the top of the first high hill which he should see immediately near Cartagena, for in that hill lived the malignant spirit which was worshipped in the form of an animal by the Indians, and whose worshippers called the spirit "Uri, Uri, Busliace, Veni." This idolatry, it is reported, was confessed by a man of mixed blood, Luis Andrea by name, many years afterward. Andrea was said to have had a pact with the devil, and this fact and his other sins were found out by the famous "Holy Office," or Inquisition, in its own mild and persuasive way. To show its full appreciation of Andrea's confession, report says, the court mentioned had him burned at the stake.

The Inquisition sat here from 1610 to 1821, and among the many interesting structures of the city is the house, now occupied as a private dwelling, where the famous judicial body held its court.

There are any number of wonderful old churches, in all styles of architecture and in all conditions of repair or ruin, now being occupied for all manner of uses. Many of them date from the sixteenth century, but the greater number were erected in the seventeenth. Among the older is the convent of Santo Domingo, occupied as a Dominican monastery to-day, and for which the King of Spain, in 1730, authorized the collection of money to be used in its repair, stating that "owing to its antiquity this convent is rapidly falling into ruin." It was erected in 1539, and is a most enchanting old place, with a chapel in which are three wonderful flat arches. The cathedral was erected soon after, and in this will be found paintings of all the former bishops, and some wonderful examples of wood carving. Here is also one of the finest samples of Italian marble in the new world. This is a pulpit which is said to have been intended for Lima, Peru. The ship in which the pulpit was shipped was wrecked at Cartagena, however, and the pulpit is said to have floated ashore. Reshipped later, the second vessel met the fate of the first, according to tradition, and the altar again appeared upon the beach. This was taken as an evidence of the Divine will that this altar should remain at Cartagena. However that may be, it is there, and admired by every lover of sculpture who sees it.

One of the prettiest chapels of the city is in connection with the hospital, formerly the convent of the

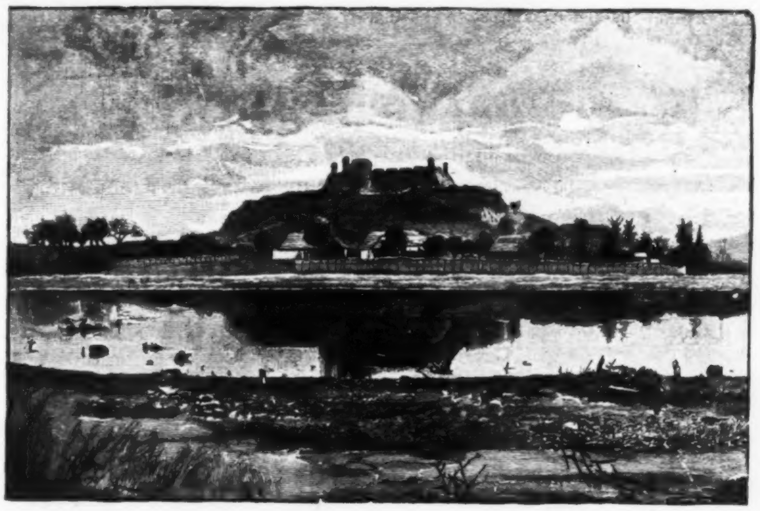
A SECTION OF THE HISTORIC WALL OF CARTAGENA, COLOMBIA.

Erected by Spain at a cost of $55,000,000 for protection against pirates. Cartagena was the port whence Peruvian gold was shipped to Europe, and is now one of the leading ports of Colombia.

THE BATTLEMENTS OF FORT SAN FELIPE DE BARAJAS, CARTAGENA, WHERE VERNON'S TROOPS WERE DEFEATED.

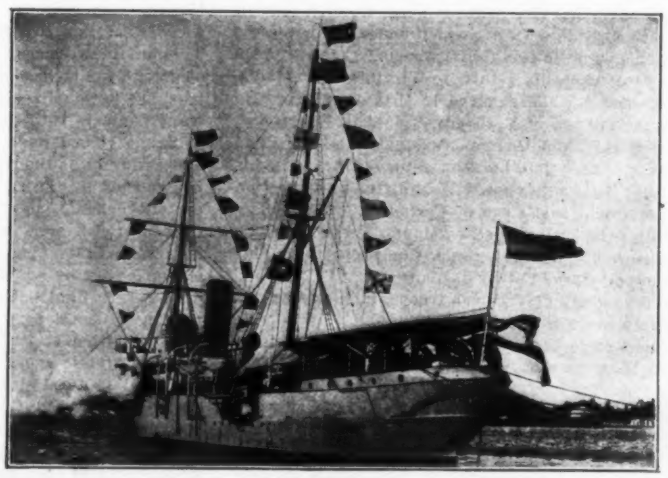
It is presumed the troops were led by Col. Lawrence Washington in this attack.

STREET SCENE IN CARTAGENA.



THE OLDEST FORTRESS IN AMERICA, CARTAGENA.

A CORNER OF THE BATTLEMENTED WALL, CARTAGENA.



COLOMBIAN MAN-OF-WAR "CARTAGENA," FORMERLY THE PRIVATE YACHT OF THE SULTAN OF MOROCCO.

CARTAGENA: "THE HEROIC CITY."

Santa Clara nuns. In this the altar is a wonderful piece of gilded carving, and the pulpit erected, nobody seems to know when, is of the most artistic workmanship, inlaid, and the panels set with beautiful paintings.

In the church of San Pedro Claver lie, in a vault beneath the altar, the bones of the famous saint whose name the church bears. Visitors are shown these bones which seem to bridge the chasm of centuries when it is remembered Claver's service as priest to the negroes was in the early seventeenth century. These are the remains of America's only saint, so far as I can learn, he having been canonized by Pope Leo XIII. in 1888.

In fact, nearly all the old churches and their contents, where the church buildings have not been taken for other uses, are worthy both time and study, for I believe that little is known of their real treasures, and that Cartagena is so little known is a source of wonder to anyone who has an opportunity to see its quaintness and know some of its rare antiquities.

San Felipe de Barajas, an old castle and fort lying on a low hill overlooking the city, is full of interesting underground passages, as are many of the fortifications, and although utterly abandoned and falling into ruin, is still a formidable stronghold.

Tradition has it that the underground passages, entrances to which are open, and which in recent years have been explored for short distances, formerly connected the stronghold with the convent of Santa Candelaria on the Popa and also with the house of the inquisition, the cathedral and the church of San Pedro de Claver, which was formerly the church of St. Jean de Dieu.

San Felipe was the most formidable of all the series of intrenchments outside the city walls, and withstood the attack of the British Admiral Vernon's soldiers after he had captured all the other forts about the harbor.

One thing that lends interest to the history of this old castle and Vernon's memorable siege of Cartagena in 1741 is that Lawrence, elder brother of George Washington, was the ranking captain of colonial troops under Vernon, and that without doubt he took part in the attack on this old fort, which ended in the defeat of Vernon's effort to capture Cartagena. Colonel Washington died after his return to Virginia from a disease contracted while engaged in that campaign. He visited the islands of Barbados, Trinidad, Nevis, etc., seeking health, and George Washington accompanied him for a while; but he soon returned home to his deathbed. It was Colonel Washington's connection with Vernon in this siege of Cartagena which led to his naming his country seat "Mount Vernon," which place after his death became the property of his brother, the future "Father of his Country." It is well known that many of Vernon's troops, in his attack on New Spain, were from the colonies.

In this article there is room to touch but incidentally on the riches of antiquity which lie open to the casual traveler who visits "the heroic city." But I feel sure, without entering upon the odiousness of comparison, that no other city on the West Indian routes of tourist travel offers so much of interest to the sight-seer as does Cartagena, the old capital of New Spain.

CARTAGENA HARBOR.

VIEW OF CARTAGENA.

CARTAGENA: "THE HEROIC CITY."

HEAT TRANSMISSION.

The earlier race of steam engineers undoubtedly achieved a very substantial success with but a very limited knowledge of the principles of thermodynamics—a knowledge which, indeed, can hardly be said to have existed during those days of pioneering. Few of us, however, nowadays, are satisfied with knowing that a certain procedure will give rise to certain results. Like the "Elephant's Child," of Kipling, we are endowed with "'satiable curiosity," and are certainly not content with the fact that a particular design of steam engine will develop 1 horse-power per hour for, say, 1½ pound of fuel, but desire to know the origin and each of the individual losses which in the aggregate prevent us from obtaining in the form of useful work more than some one-seventh of the chemical energy originally existent in the fuel consumed. It cannot, perhaps, be claimed that the detailed analyses of the various sources of loss have led to any very notable improvement in this ratio, but the mere assurance that the bulk of these losses are inherent to the conversion of the heat into mechanical work has undoubtedly saved much misdirected labor, and enabled the engineer to concentrate his attention on the problem of reducing to a minimum the non-inherent losses.

The steam boiler, though as old as the steam engine, has been studied much less minutely, so far as concerns the principles involved in the transmission of the heat from the fuel to the water. At first sight, indeed, the field for successful research appears less attractive. In one way or another an efficiency of heat transmission of between 70 to 80 per cent has long been attained with boilers of practically every pattern, and to leave well enough alone is a very good rule in the practical business of life, whatever it may be in philosophy and science. The enormous discrepancy, however, which an elementary calculation shows to exist between the conductivity of iron as accurately measured in the laboratory, and its apparent conductivity as realized in boiler practice, was, however, far from satisfactory once it was realized; and engineers are certainly much indebted to those laborious investigators who have cleared the matter up.

It may now be taken as certain that in ordinary boiler practice the metal on the fire side of a tube is never more than a few tens of degrees hotter than the water which it is converting into steam, although the average temperature of the gases passing through may be 1,000 deg. F. or more. In fact, the interchange of heat between a gas and a solid takes place with exceeding difficulty, in spite of the remarkable mobility of the gaseous molecules. It seems, indeed, to be satisfactorily proved that in ordinary conditions the surface of a boiler tube is separated from the core of hot gas passing through it by a very thin film of cool and nearly non-conducting gas, which, as it were, blankets the surface. Mr. Mark Robinson has suggested that this cool film consists of molecules which have lost their velocity in communicating their kinetic energy to the molecules of the plate. This is probably true, but it would seem that each molecule must make many contacts with the plate before it can deliver up to it any considerable proportion of its energy. This will certainly be the case if the transference of energy is governed by the rules applicable to the collision of perfectly elastic spheres. In the solid condition the molecules of a metal probably consist of many atoms, and weigh, therefore, perhaps 200 times as much as the molecules by which they are bombarded. If, however, a very light but perfectly elastic sphere in rapid motion strikes a very heavy elastic sphere at rest, it rebounds from it with nearly undiminished velocity, and the kinetic energy transferred, when the heavier body weighs 200 times as much as the lighter, is only about one-fiftieth of the original total. In other words, the absolute temperature of the gaseous molecule would in a single contact with another, 200 times heavier and at rest, be reduced 2 per cent.

The molecules of a solid, moreover, are not free, and this increases their effective mass, so that the actual transfer of energy may well be even less than that just assumed. In fact, a considerable number of blows are necessary before the temperature of the gaseous molecule is reduced to that of the plate. These repeated collisions, however, follow as a matter of course from the laws governing the diffusion of gases, in which process the path of each individual molecule is what has been termed the "toper's tour." Each moves, in short, just as if it were a man so inebriated that he falls down at each step he takes, and is so lost to all sense of direction that each successive step is as likely to be backward as forward, to the right as to the left. Under such conditions the probability of his attaining, in the course of an hour, any considerable distance from his starting-point is extremely small. Similarly, each gaseous molecule is continually coming into a collision with another, and after each collision it darts off on a fresh path, the direction of which is absolutely at random. The progress of a molecule in any stated direction is therefore exceedingly slow. Thus in the case of still air at ordinary temperatures, although the molecules are moving with a velocity which averages some 1,300 feet per second, it has been calculated that, on the average, each only moves from its original position by about ¼ inch per second.

Moreover this ¼ inch may lie in any direction. Thus, if the gas were confined in a tube, the molecule which struck the wall at one moment would one second later be ¼ inch away from its starting-point, but this ¼-inch displacement need not necessarily be in the direction of the center of the tube. Hence the molecules which strike the wall at any instant will one second later be on an average only ¼ inch from the wall. Actually the distance will be greater than this, because the wall forms an absolute limit to the motion of the molecule, preventing peregrinations outside. Nevertheless, the actual displacement will be of the same order as the foregoing, so that the random motion of the molecules appears to afford an adequate explanation of the existence of the non-conducting film of cold air which experiment has proved to line surfaces, absorbing or transmitting heat. The same molecule, owing to this phenomenon, tends to come again and again into contact with the tube, in place of making way for a hotter one. In these repeated shocks it parts with more and more of its energy, losing temperature at each rebound. As a loss of temperature corresponds to a decrease of velocity, after each contact the molecule becomes less and less able to make its way, through the crowd, toward the hot center of the tube. It would seem, therefore, that had we to rely on diffusion only for the transmission of heat from a hot gas to a plate, the process would be exceedingly slow. Fortunately, however, by establishing a rapid current of gas through the tube, the spent molecules can be swept away and replaced by hotter ones. The practical effect of this is that the thickness of the spent film is reduced and the hot molecules have to diffuse through a thinner layer in order to reach the wall. With very rapid currents a really remarkable rate of heat transmission can be obtained, a notable example being the tuyeres of a blast furnace, where, if our memory serves us, heat passes through the metal at a rate which is of the order of 200,000 B.T.U. per square foot per hour. A rapid current, therefore, promotes the transfer of heat, although it is common knowledge that boilers worked under heavy forced draught give a low evaporative efficiency. In these cases, however, the rapid current is maintained through the fire as well as through the tubes, while the desideratum is the combination of a moderate rate of combustion with a very rapid current through the flues. That this combination is possible appears to be proved, as well as the added fact that it results in a very notable reduction of the heating surface required for the generation of a given quantity of steam. In some special cases the advantage thus gained may offset the drawback of very considerable fan-power then necessary; but so far as ordinary boiler practice is concerned it will in all probability turn out that the usual methods of construction and operation cannot with profit be varied to any great degree. Tests made with locomotive boilers many years ago have shown that, with the same rate of combustion per square foot of firegrate, the same evaporation is obtainable with half the tubes blocked as with the whole in effective use, but the cost of providing for the additional draught has prevented designers from taking any advantage of this experience. In surface condensers, on the other hand, considerable benefit has resulted from a realization of the importance of the velocity factor in promoting the transfer of heat. As a consequence, a modern condenser will maintain a high vacuum with less surface than an old-time one.—Engineering.

THE TERCENTENARY OF THE TELESCOPE.

WHAT THE TELESCOPE HAS ACCOMPLISHED.

BY J. L. E. DREYER.

The year 1609 is one of the most remarkable epochs in the history of astronomy. In the summer of that year Kepler's book on the motion of Mars was published, in which for the first time the actual orbit of a planet in space was determined, while astronomers had hitherto only been able, with more or less success, to investigate the projection of that orbit on the celestial sphere. In the same year the newly-invented telescope was directed to the heavenly bodies, and enabled mankind to form an idea of their constitution, instead of being, as hitherto, reduced to making wild guesses on this subject. But while many years had to pass before Kepler's work became generally recognized (even Galileo never accepted it), the telescope at once became an indispensable tool to astronomers.

Though many attempts have been made to prove that some of the ancient or mediæval philosophers made use of telescopes, it is now generally acknowledged that the telescope was not known to anyone before the year 1608.* On October 2nd of that year Johan Lipperhey, a spectacle-maker of Middelburg, submitted to the States General an instrument for seeing at a distance, which he had invented, "as was known to the members of the States," and demanded either a patent for thirty years or an annual pension. The States General desired the inventor to produce a binocular telescope, and when he did that they eventually paid him 900 florins for three instruments of this kind, while the patent was refused on the plea that the invention had already become known to many people. These facts are certain enough, but it is quite possible that Lipperhey may not have been the first to construct telescopes, but that the claims of Zacharias Jenssen, another spectacle-maker of Middelburg, may be well founded. It appears that this man had invented a compound microscope in 1590. A story was current early in the seventeenth century that some children, while playing with lenses, had found that a weathercock viewed through two of them appeared much enlarged and turned upside down, and that this led to the invention of the telescope. But a telescope which produces an inverted image must have been the so-called astronomical telescope soon afterward invented by Kepler, which has a convex eye-lens, and not the Dutch or Galilean telescope with a concave eye-lens of which the modern opera-glass may serve as a specimen. A man who had invented a compound microscope would not be unlikely to possess lenses good enough to produce a fair image of a weathercock, and to have been capable of modifying this accidental discovery by substituting a concave eye-lens to make the image upright. Some person is said to have gone to Middelburg to procure a telescope from the spectacle-maker there, but to have applied, by a mistake, to Lipperhey, who thus first heard of the invention.

Whether Lipperhey or Zacharias Janssen was the first to make telescopes will probably never be settled with absolute certainty, but in any case the first telescopes were undoubtedly made in Middelburg. In the introduction to the catalogue of his library (p. xviii), Libri describes a small tract printed at Lyons and dated November 12th, 1608, in which mention is made of "nouvelles lunettes" made by a poor, pious and God-fearing man of "Mildebourg;" and the writer states that "even the stars which ordinarily do not appear to our view and our eyes on account of their smallness and the weakness of our vision may be seen by this instrument." From several other contemporary sources we know that knowledge of the new invention spread very rapidly, so that telescopes were not difficult to procure in the spring of 1609, both in the Netherlands and elsewhere. In December, 1608, the States General sent two telescopes made by Lipperhey to King Henry IV., of France; others were publicly offered for sale in Paris about the end of April, 1609, while the news of the invention had reached Venice in December, 1608, and a specimen of the new instrument was brought to Milan in the following May. The wonderful new toy was so very simple that it is not strange that "there was nobody who did not say he invented it," as a contemporary writer tells us. Among these was Galileo, who in August, 1609, on the Campanile of San Marco at Venice, exhibited a telescope made with lenses purchased in that city. He claimed to have merely heard that a certain Belgian had presented to Prince Maurice of Nassau a glass by means of which distant objects were seen as clearly as if they were quite near, and that this meagre information sufficed to enable him in a single night to design a telescope. If the information received by Galileo was really as scanty as he says, it is very strange that the man who from it constructed a telescope should shortly afterward in his "Sidereus Nuncius," show that he hardly had grasped the most rudimentary notions as to the passage of rays of light through lenses and the formation of images. He would have done better if he had followed the explanation of the effect of convex and concave lenses given by Kepler in his book on optics, published in 1604.*

But even if we cannot give Galileo the credit which he demanded of having re-invented the telescope, and though, as we have seen, others before him had pointed a telescope to the stars, he deserves full credit for having at once grasped the great possibilities offered by the instrument, and for having made the first serious attempt to explore the heavens with it. He did not grind the lenses himself, but made use of such as he could purchase. Judging by the very rough sketches of the lunar surface given in his little book "Sidereus Nuncius" (published in March, 1610), his small telescopes, magnifying from three to thirty diameters, cannot have been very good; still, they were sufficient to show that the moon was a body like our earth, having mountains and plains, that the Milky Way really was composed of innumerable stars; and, above all, they enabled him to discover the four satellites of Jupiter in January, 1610. Continuing his work, he detected in the following autumn the phases of Venus and Mars, and about the same time he became greatly puzzled by the peculiar appearance of Saturn, which planet, instead of showing a round disk seemed to be "triple." This continued to be an unsolved riddle for nearly fifty years, until Huygens, by using much improved telescopes, showed that it was caused by a detached flat ring round the planet.

In the meantime other observers lost no time in taking up the new study of the heavens. Before the end of 1608 Simon Marius, of Anspach, procured a telescope with which he found the satellites of Jupiter one day later than Galileo did. He continued for some years to follow their motions with great perseverance and skill, and produced valuable tables of them in his "Mundus Jovialis," published in 1614. Unfortunately, he roused the jealousy of Galileo, who accused him of plagiarism, an accusation which, up to a few years ago, most historians of science were inclined to consider proved, but which has now been thoroughly disproved by a detailed study of the observations of Marius by Oudemans and Bosscha. Marius was also the first to notice the phases of Mercury and the spurious disks of the fixed stars, which the imperfect telescopes of Galileo had failed to show. Even to the sun was the new instrument directed; Galileo says he saw the sunspots in the summer of 1610, but he does not seem to have taken any interest in them at first, and did not, as usual, announce the discovery, either openly or through an anagram. Thus Johan Fabricius was the first to publish the discovery of sunspots early in 1611, though Galileo made up for his hesitation by systematic observations, and by being the first to recognize that the spots are formations at the surface of the sun itself, and not bodies moving round the sun, as Scheiner, the third and most assiduous observer of sunspots, for a long time maintained.

The Dutch or Galilean telescope did not for long remain the only telescope used by astronomers. Already in 1611 Kepler published his "Dioptrice," in which he clearly showed the effect of combining various lenses and the advantages of the "astronomical telescope," in which the real image of the object is formed by the object-glass at the focus of the latter, which is viewed through a magnifying convex eye-lens. A year or two later Scheiner, and following him Fontana, actually constructed and made use of telescopes of this kind, while the inconvenience of the inverted image produced by them was obviated by the introduction of an additional lens in the "terrestrial telescope" to re-invert the image formed by the object-glass. The importance of the real image, which allows a wire or a wire-cross placed at the focus to be seen through the eye-piece as sharply as, and coinciding with, the image, was recognized about 1640 by William Gascoigne, who applied a telescope to a quadrant for measuring altitudes, an application which had been suggested in 1634 by the French astrologer Morin, who, however, only possessed a Galilean telescope. Outside England, Gascoigne's idea probably remained unknown, and it was not until 1667 that Auzout and Picard applied telescopes to measuring instruments, and thereby immensely increased the accuracy attainable in astronomical observations.

The importance of the invention of the telescope for the advancement of astronomy is not to be measured only by the insight it gave into the nature of the heavenly bodies, and the aid it rendered in following their movements more accurately. It also rendered an important service by making the Copernican system appear more natural and reasonable in the eyes of every unprejudiced thinker. Hitherto this system had probably to most people appeared to be nothing but a new way of "saving the phenomena" (to use an expression of the ancients), that is, a new method of calculating the motions of the planets, which anyone might use, whether he believed in the reality of the earth's motion or not. Two circumstances had contributed to give an appearance of unreality to the new system; first, the numerous epicycles which Copernicus had been compelled, like the ancients, to use in his planetary theories (because he did not know the first two of Kepler's laws, and therefore had to confine himself to combinations of circles), and secondly, the spurious preface which, without the knowledge of Copernicus, had been added to his book, in which the system was spoken of as a mere hypothesis which need not be supposed to be true. To assume the earth to be one of the planets was also a difficult thing, so long as absolutely nothing was known about the other planets. As to the moon, the ancients had supposed that it must be a body rather like the earth, and the telescope only confirmed this hypothesis. But adversaries of the Copernican system had always asked how the earth could carry the moon along with it during the annual motion round the sun, or why the moon alone should form an exception to the general rule by moving round a planet instead of round the sun? Now Galileo could point to the undeniable fact that Jupiter, during its orbital motion, carried four satellites or moons along with it. The discovery of the phases of Venus and Mercury deprived opponents of Copernicus of another favorite weapon, for they had been wont to proclaim that if Venus moved round the sun it ought to show phases like the moon. Again, the discovery of sunspots, objects of a temporary nature, supplied a very striking proof that the Aristotelian doctrine of the immutability of all things celestial would have to be given up. While the analogy between the earth and the planets grew stronger every day, it was also of great importance that the fixed stars in the telescope appeared as mere luminous points, so that the apparent diameters of several minutes attributed to them by all previous observers were proved to have no existence. This put an end to the serious objection raised by Tycho Brahe, the greatest practical astronomer since Hipparchus, that a star having no annual parallax and yet showing a considerable apparent diameter must be incredibly large.

As it were in a twinkling of an eye, the whole aspect of the universe had been changed by the invention of the telescope. That this was felt in some way, even by determined enemies of the idea of the earth's motion, may be seen from the statement made by Clavius, the chronologist, in 1611, that astronomers would have to look out for a system which would agree with the new discoveries, as the old one would not serve them any longer. The question could no longer be, "Do you believe in the earth's motion?" It could now only be whether the arguments in favor of this motion were becoming so irresistible that the safest thing to do for its opponents would be to proclaim the doctrine to be heretical. This was accordingly done little more than seven years after the invention of the telescope.—Nature.

* See in particular Thomas Henri Martin's Paper, "Sur des Instruments d'Optique faussement attribués aux Anciens par quelques Savants modernes," in Boncompagni's Bulletino, iv., 1871.

* "Opera ed. Frisch," i., p. 56.

The pressure per square inch that water exerts at each foot of depth is expressed in the case of sea water weighing 64 pounds per cubic foot by the equation—

$p = 0.4444\,y + 0.000000293\,y^2$, in which p represents the pressure and y the depth in feet beneath the free surface.

In the case of fresh water weighing 62 pounds per cubic foot, the results given by the above equation would require to be multiplied by 62/64; and, for any other density, the resulting pressure will be as many sixty-fourths of the pressures computed from the above equation as there are pounds of weight to the cubic foot.

THE EFFECT OF TIDES ON THE EARTH'S CRUST.

THE WORK OF DR. HECKER AT POTSDAM.

BY CH. LALLEMAND.

As the different parts of the earth are unequally distant from the moon, they are unequally attracted by that satellite. The attraction is greater in the hemisphere turned toward the moon, and less in the opposite hemisphere, than it is at the earth's center. The difference in attraction produces the effect of a small disturbing force, which causes a plumb line to deviate slightly toward the moon in the first-named hemisphere and away from the moon in the opposite hemisphere, and which also raises the surface of the ocean in two protuberances around the point directly

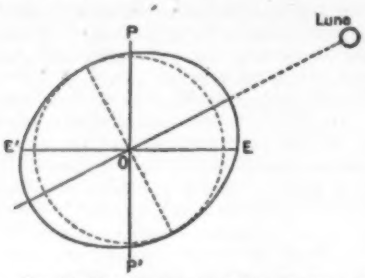


Fig. 1.—Double Protuberance of the Surface of the Ocean Caused by the Moon's Attraction.

P, P'. Earth's poles. E, E'. Equator.

beneath the moon and the antipodal point. (Fig. 1).

In consequence of the (apparent) revolution of the moon around the earth, in 24 hours and 50 minutes, these protuberances revolve in the same period, producing at every point of the coast two daily tides, which are of unequal heights except when the moon is at the equator. The sun acts in a similar manner but, as its greater mass does not compensate for its greater distance, the solar tides are only about half as high as the lunar tides. The two effects are added together at new and full moon, when the earth, sun and moon are nearly in the same straight line, but at the moon's quarters, or quadratures, the elevation caused by the moon is half neutralized by the depression due to the sun.

Tides are not confined to the liquid mass of the oceans. The earth itself is subject to the same influences and experiences similar deformations, which, however, are not easily observed.

No movement can be detected without a fixed point of reference. For the tides of the ocean such points are furnished by the coasts, and the tides can be observed only on the coasts. If the earth were entirely covered by water and men lived on floating islands the existence of tides would never have been suspected. This is exactly our position in relation to tidal movements of the earth's crust. We have no fixed points of reference, and are compelled to attack the problem by a different method.

The deviation of a plumb line by the moon's attraction has already been mentioned. The sun produces a similar deviation and the combined effect of

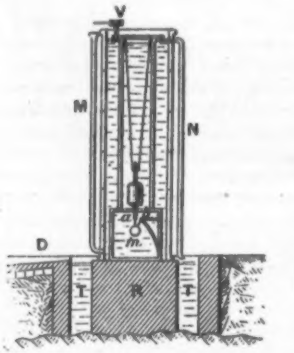


Fig. 2.

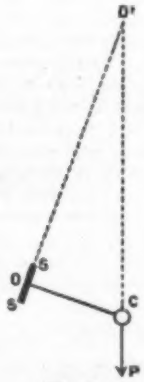


Fig. 3.

Fig. 2.—Sir G. H. Darwin's Vertical Pendulum.

M, N. Concentric water jackets to insure constancy of temperatures; R, pillar built on the rock; T, trench filled with water; D, spillway; m, mirror suspended by two threads from the point of the pendulum a and a fixed point b near it.

Fig 3.—Diagram of Horizontal Pendulum.

the two luminaries varies with their positions, causing the plumb bob to describe a very small closed curve. The masses of the earth, moon and sun and their relative positions at every instant being known, the corresponding deviations and the curve described by the plumb bob can be calculated. If the earth were perfectly rigid the curve thus computed would coincide with the curve actually described, while if the earth were entirely liquid its surface would be normal to the varying direction of the plumb line at every point and no motion of the bob with reference to the surface could be detected.

As the crust of the earth is not perfectly rigid, it becomes slightly deformed under the influence of tidal action and consequently the deviation of the plumb line, relatively to the earth's surface, is less than the theoretical deviation computed on the assumption of perfect rigidity. If the actual deviation could be measured, it would afford means of estimating both the extent of the tidal displacement and the coefficient of rigidity.

This measurement is attended by two serious difficulties. The deviation is very small, less than 0.01 inch, so that the terminal point of a pendulum 40 inches long could never pass outside a circle 1/250,000 inch in diameter. Furthermore, the superficial strata of the crust are warped by the heat of the sun and this deformation produces an apparent deviation of the pendulum in a direction opposite to the deviation by solar attraction. The latter is only about 0.005 inch, but the thermal deviation is 100 times as great (0.5 inch) at the earth's surface, and 10 times as great (0.05 inch) at a depth of 82 feet.

Though it would appear impossible to separate the two effects, the task has been attempted, within the last 75 years, by several eminent scientists. D'Abbadiè, Zoellner, Bouquet de la Grye, Lord Kelvin, Sir George Darwin (Fig. 2) and Wolf have successively, but in vain, devised very delicate and sensitive apparatus for the measurement of the deviations of the pendulum.

Fig. 4.—Hecker's Crossed Horizontal Pendulums.

Within the last fifteen years more encouraging results have been obtained by De Rebeur-Paschwitz, Kortazzi, and Schweyder, by the employment of the horizontal pendulum.

In order to measure, with a vertical pendulum of the ordinary type, deviations as small as those here considered it would be necessary to use a pendulum of enormous length. The same result can be attained by placing the axis of rotation of an ordinary pendulum (*S S*, Fig. 3) in a nearly vertical position. The pendulum is thus made equivalent to a very long vertical pendulum *O' C*, oscillating about the point *O'* at the intersection of the axis of suspension *S S* and the vertical through the center of the bob *C*. This length can be determined by causing the pendulum to oscillate with its axis successively in the inclined and the usual position. The effective lengths are proportional to the squares of the periods of oscillation in the two portions, and the angular deviations are in the inverse ration. From the deviation of the horizontal pendulum the deviation of the plumb line can be easily deduced.

The most remarkable experiments which have been made with this instrument are those which were conducted by Dr. Hecker, at Potsdam, between 1902 and 1909, with an apparatus (Fig. 4) comprising two round horizontal pendulums, installed in an underground chamber of constant temperature and humidity, 82 feet below the surface. The images of a luminous point, reflected by two small mirrors attached to the pendulums, were continuously photographed upon a distant cylinder which was covered with sensitive paper and turned by clockwork. This combination of mechanical and optical enlargement made each horizontal pendulum equivalent to an ordinary pendulum as long as the height of Mount Blanc. The observations were combined so as to determine the solar and lunar effects separately. The solar effect, shown in Fig. 5, is chiefly thermal, the maximum and minimum deviations (±0.025 sec.) occurring about 6 o'clock, morning and evening, simultaneously with the maximum and minimum temperatures of underground rooms. The much larger curve of lunar deviation is shown in Fig. 6, surrounded by the still larger ellipse which the

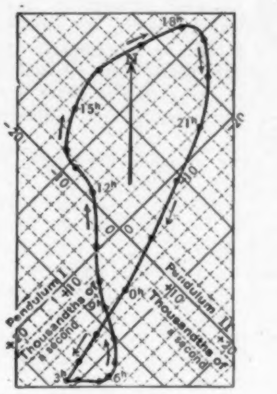


Fig. 5.—Mean Apparent Daily Movement of Pendulum Point Caused by the Sun.

front of the pendulum would describe if the earth were perfectly rigid. The mean semi-diurnal lunar deviations along and perpendicular to the meridian are compared in the following table:

Direction deviation in thousandths of a second of arc.

	Theoretical.	Observed.	Ratio.
East and West....	±10	±7.7	0.77
North and South..	± 8	± 3	0.37
Mean Ratio...........................			0.55

The decrease of deviation caused by the elasticity of the earth's crust is twice as great along the meridian as along the parallel of latitude. Hence, according to a formula found by Schweyder the rigidity in the latter direction is eight times that in the former.

New measurements made on other continents would show whether this difference is due to the apparatus or its installation, to the structure of the earth's crust at Potsdam, or to the general tetrahedral deformation of the globe which might be expected to make the rigidity greater in the direction of the European-Asiatic edge of the tetrahedron, which passes near Potsdam, than at right angles to that edge.

In earlier experiments with the horizontal pendulum the observed deviations were equal to 2/3 the calculated deviations. According to Lord Kelvin, Sir George Darwin and Schweyder the oceanic tides of long period (monthly and semi-monthly) likewise have only 2/3 the theoretical amplitude, calculated for a rigid globe.

The earth's poles are also subject to an oscillation of a few yards each way, which cause the latitude of

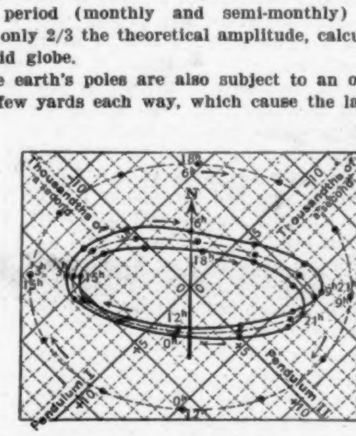


Fig. 6.—Mean Apparent Daily Movement of Pendulum Point Caused by the Moon.

——— observed movement
— . — . — mean semi-diurnal movement
. . . . theoretical semi-diurnal movement

every point of the earth's surface to vary to the same extent. If the earth were absolutely rigid the period of this oscillation would be 305 days, but the elasticity of the earth increases the mean period to 436 days. I have shown that this increase in the period of oscillation of the poles corresponds to a reduction of the height of ocean tides to 7/10 its theoretical value.

Hence the value 2/3, for the coefficient of reduction may be regarded as nearly correct. The corresponding value for the rigidity of the earth is greater than that of copper and 5/6 that of steel.

In these conditions the tides of the earth's crust would be as great as those of the ocean. At the equator, the amplitude of the lunar tide would be about 13½ inches, and that of the solar tide 6 inches, which would produce combined tides of 19½ inches at equinoctial new and full moons and of 7½ inches at equinoctial quadratures. In the latitude of Bordeaux these earth tides would be diminished one-half and at the poles they would be reduced to nothing.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

INSECTS VS. FIRES.

TWO METHODS OF FOREST DESTRUCTION.

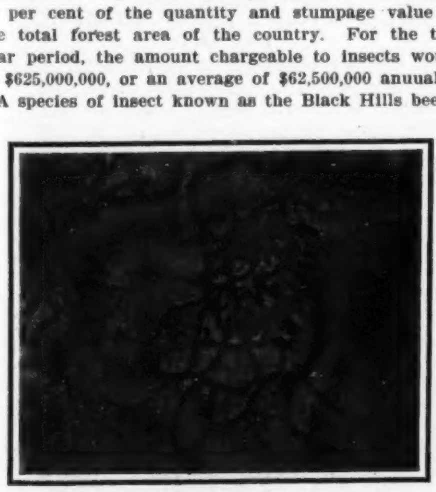
BY CHARLES RICHARDS DODGE.

SOME startling statements have been made recently by Dr. A. D. Hopkins, of the National Bureau of Entomology, in relation to the money loss to the country from the devastation of forest insects. We hear so much in the present day regarding the rapid deforesting of the country for commercial ends,—in the production of the many forms of lumber, in the manufacture of wood-pulp, etc., and also through the agency of forest fires, that the damage caused by a few species of insignificant beetles is almost wholly lost sight of. Dr. Hopkins' figures throw new light on the subject, showing as they do that the losses from the attacks of insects are of far more serious consideration than the destruction from the forest fires which occur in every section of the country.

Recalling a recent statement that, at the present rate of cutting, all of the spruce forests will have been ground into pulp-wood in another decade, it is an interesting fact that forest fires wipe out in a single year the equivalent of a two years' cut of pulp-wood. The cut for the year 1907 cleared an area of something like 435,000 acres of forest growth, the product being valued, by the acre, at $32,000,000. Mr. T. Cleveland, of the United States Forest Service, estimates that, on the average, since 1870, forest fires have cost the country annually $50,000,000, in the value of the timber destroyed. For many years Dr. Hopkins has made forest insects his special study, and from investigations carried on by himself or his assistants he estimates that the average annual loss to the whole country from forest destruction by insects amounts to a matter of $62,000,000.

The estimate of the area and stand of the present forests of the United States as given in a recent publication of the Forest Service is two trillion five hundred billion feet (2,500,000,000,000) board measure. The average stumpage value has been stated at $2.50 per thousand feet board measure, making a total value of the standing merchantable timber of $6,250,000,000. In considering the amount of standing merchantable timber killed by insects, and the amount of standing timber living, dying or dead, which has been reduced in quantity and value through their agency during a ten-year period, Dr. Hopkins estimates that such timber represents an equivalent of more than 10 per cent of the quantity and stumpage value of the total forest area of the country. For the ten-year period, the amount chargeable to insects would be $625,000,000, or an average of $62,500,000 annually.

A species of insect known as the Black Hills beetle



GALLERIES IN PINE TIMBER, SHOWING HOW THE BARK IS SEPARATED FROM THE WOOD BY THE WESTERN PINE BEETLE.

killed approximately 1,000,000,000 feet, board measure, of timber during a period of ten years, which at $2.50 per thousand feet would amount to an annual loss of $250,000. This is merely one example of very destructive depredation by a single species of bark-beetle in a single national forest of a million and a quarter acres. The average losses from fires on the national forests of the United States from 1905 to 1908, inclusive, are estimated by Mr. Cleveland to amount to but $165,000 annually. Even a portion of this fire loss is indirectly chargeable to insects, as they contribute to such losses by furnishing a ready means for the spread of fires over large areas which, otherwise, might have been confined within narrow limits. In many cases it has been found that after insects have killed the timber over extensive areas, the standing and fallen dead trees have furnished fuel for great forest fires which have not only destroyed or charred the dead timber, but killed the living timber and reproduction, and swept on into adjacent areas of healthy timber. Abundant evidence has been found in recent investigations to indicate that some of the vast denuded areas in the Rocky Mountains and other sections of the country are primarily due to widespread devastations of insects, and that subsequent fires destroyed the timber and prevented reproduction. It is also evident that a considerable percentage of dead timber, and especially that found in coniferous forest regions, generally believed to have been fire killed, is a result of primary attack by insects. While a vast amount of timber has been killed outright by forest fires, in almost every case observed, insects have contributed to a greater or less extent to the death of recently fire-injured trees which might otherwise have recovered, and especially to the rapid deterioration of the wood of a large percentage of killed trees.

INSECT-KILLED PINE TREES.

Two dead pine trees are shown standing in what was formerly a large northeastern forest area. Seventeen years ago the section was visited by a sudden invasion of bark-beetles, which killed a high percentage of the trees. Up to that time, forest fires had done comparatively little damage, and were small affairs, but since the attack and subsequent death of the trees, this forest area has been visited by several very destructive, and extensive, forest fires. The tree in the left of the picture gives evidence of having been struck by lightning and the trunk partly burned. This is an example, out of many cases that could be cited, which furnishes evidence that lightning striking a dry, insect-killed tree may start a disastrous fire. And there is every reason to believe that many fires supposed to have been started by man's carelessness, are due to lightning striking a dry, dead and insect-ridden trunk, which, leaping into flame, starts a conflagration which burns both dead and living trees over a vast area. In the statistics of forest fires, no one will ever know how many millions of feet of insect-killed timber is included.

Regarding the durability of standing timber killed by insects, some interesting statements are made which present another phase of the question of losses by insect depredation. As a general proposition it may be said that timber killed by insects and fire would be available for utilization for many years were it not for injuries through the secondary attacks of wood-boring insects, and the destruction of insect-killed timber by forest fires. As an example it may be stated that larch trees which evidently died as a result of defoliation by the larch-worm between 1881 and 1885 were sound enough in 1908 to be utilized for railroad ties and other purposes. In this instance the killed timber had escaped subsequent injury from wood-boring insects and from fire.

So far, only damage to standing or living timber has been considered. Unfortunately, the destruction does not cease here, for when we take into account the aggregate loss to the dealers in the sawn lumber, and to the manufacturers of the finished product—to the trade and to the consumer—the total will be increased many millions of dollars beyond the estimated losses from trees killed in the forests. Hardwood lumber of all kinds, rough handles, wagon stock, etc., made partially or entirely of sap-wood, are often reduced in value from 10 to 90 per cent by a class of insects known as powder-post beetles, the sap-wood of hickory, ash and oak being most liable to attack. During the past few years the reported losses from this source of injury, on account of reduced values, might range from 5 to 10 per cent. Tan-bark is quite liable to attacks of insects, and in some tanyards 50 to 75 per cent of the 3-year-old bark is destroyed. In one West Virginia tannery more than $30,000 worth of bark was destroyed in this manner. Such finished products as axe and other tool handles, wagon, carriage and machinery stock—especially manufactures from hickory and ash—held by the trade, or stored, often in vast quantities by the army and navy, are subject to more or less serious injury, the extent of which, if stated in dollars and cents would make a tremendous showing. When once attacked material of this kind is usually rendered worthless for the purposes indicated and must therefore be replaced by new material. It is estimated that the losses upon such materials have amounted to from 10 to 50 per cent.

Construction timber and other woodwork in houses, in bridges and like structures, as well as railroad ties, telegraph poles, fence-posts, mine props, etc., which are frequently injured by wood-boring larvæ, black and white ants, carpenter bees and powder-post beetles, are sometimes reduced in efficiency from 10 to 100 per cent.

While forest trees are often injured, or killed outright by defoliation due to a sudden invasion of some leaf-eating species, by far the most destructive agency has been found to be certain species of bark-boring beetles, which literally girdle the living trees by boring galleries and mines in every direction around the

BARK SEPARATED FROM THE WOOD BY GALLERIES OF THE SOUTHERN PINE BEETLE.

main trunks. On all forest areas there will be more or less damage from this source of injury, but it frequently happens that certain species of insects appear in such vast numbers as to become an invading army of destruction. In 1890-1892 such an insect invasion of forests occurred, extending from West Virginia through Maryland and Virginia and into North Carolina on the south, and into Pennsylvania on the north, covering an area of 75,000 square miles. In this instance the enemy was the southern pine beetle, and its operations were conducted against pine and spruce trees chiefly, although shade and ornamental trees also suffered greatly. In portions of this area all of the pines and spruces growing upon thousands of acres

were killed. Fig. 3 illustrates how the trees are killed.

Almost as destructive a species is the eastern spruce beetle, which works in the forests of New York, New England and Southeastern Canada. From time to time there have been outbreaks of this species resulting in the destruction in the aggregate of many billions of feet, board measure, of the finest lumber, and the devastation of thousands of acres of forest lands. In the Rocky Mountain region outbreaks of the Engleman spruce beetle have killed in some sections 75 to 90 per cent of the timber of merchantable size. Still another exceedingly destructive species is the Black Hills beetle, which, during the past ten years, has destroyed a large percentage of merchantable timber in the Black Hills National Forest of South Dakota, as previously referred to. Two other species of pine beetles operate still farther west in the cascade range and southward through the Sierra Nevadas. In one locality in Northeast Oregon it is estimated that 90 to 95 per cent of the timber in a dense stand of lodge-pole pines covering an area of 100,000 acres has been killed within three years by a species of beetle known as the mountain pine beetle, and throughout the sugar pine districts of Oregon and California a considerable percentage of the best trees is dead. See Fig. 4.

The Douglas fir beetle is another very destructive species, while other near relatives depredate on the pines of New Mexico and Arizona. All of the above species are members of the genus Dendroctonus, which represents the most destructive enemies of the principal coniferous tree species of American forests—and at the same time the easiest to control.

In the Eastern United States the hickory bark beetle (a species of scalytus), causes great destruction of hickory timber throughout the Northern tier of States from Wisconsin to Vermont, and southward through the Atlantic States to Georgia.

From 50 to 100 per cent of the larch trees growing over vast areas of the Northeastern United States have been killed by defoliation since 1880, in outbreaks of the larch worm, the losses running into billions of feet of merchantable sized lumber.

These are a small part of the insect enemies of forest trees, for the list in its entirety is a long one, and all kinds of trees seem to have one or more destructive insect enemies. The many kinds of oak, chestnut, beech, whitewood, poplar, elm, locust, etc., all have been attacked at times, or in a lesser degree at all times, and in many cases, even when a tree has not been killed outright, its quality as hardwood lumber has been seriously impaired, to an extent frequently amounting to a reduction of value from 25 to 75 per cent.

The question may be asked if a tree dead from the attacks of bark beetles has any value as timber. As an answer, it may be said that timber killed by bark borers is not necessarily rendered useless for lumber, as some species of trees might be available commercially during periods of from one to twenty years were it not for the fact that such dead trees are further attacked by other insects—species of wood-boring beetles which extend their burrows in all directions through sound sapwood and heartwood alike, thereby hastening deterioration and decay. Thus dead timber which otherwise would be commercially valuable suffers injury and deterioration from 25 to 100 per cent. An example of the destructive work of this class of insects may be cited in the case of areas of cypress trees, in a Southern State, deadened by the lumbermen and left standing until sufficiently dry to be floated. Such trees, at certain seasons have been attacked by Ambrocia beetles and pin-hole borers, and the timber damaged to the extent of a reduction in value from 25 to 75 per cent. In some instances millions of feet of timber have been damaged in this manner. The same class of borers will attack freshly sawed hardwood placed in close piles during warm, damp weather, from June to September. In one instance a lot of several thousand feet of highest grade mahogany timber sawn from imported round logs and piled with lumber sticks between the tiers of plank, was attacked, and within a few weeks the beetles had entered the wood to such an extent that its value was impaired one-half. Heavy 2-inch to 3-inch stuff is liable to attack even when loosely piled, and heavy square timber may be badly damaged, especially when the bark has been left on the edges.

It will be seen by the foregoing that whatever system or conservation may be adopted in regard to our remaining forest areas, two agencies must be recognized which are bound to annually reduce these areas without a money equivalent; and it should be recognized, also, that the money loss to the country from either cause is far too large to be ignored. This leads to the question of insect control. That the destruction of forest trees, lumber, and manufactured products by insects can be controlled with little or no ultimate cost over that involved in good forest management and business methods, has been demonstrated in recent years through the extensive investigations and practical applications of those who have made the subject their especial study. It is stated that if the information now available through publications of the Department of Agriculture, and through direct correspondence with its experts, is properly utilized in the future, it will result in the prevention of an equivalent of at least 30 per cent of the estimated annual destruction from insect attacks in recent years, and conserve the present forest areas to that extent. How to control these foes of the forest is too long a story for these pages. Those who are interested in the matter, therefore, will do well to communicate with the Department of Agriculture direct.

ROOSEVELT'S TROPHIES.

STRANGE ANIMALS SHOT BY THE EX-PRESIDENT.

THE many specimens of skins and skulls that have come to the United States National Museum from the Smithsonian African Exposition, under Col. Theodore Roosevelt, have brought to light some names of animals that frequently fail in any way to identify the animal. Of this character are klipspringer, topi, hartebeest, wildebeest, gazella, impalla, dikdik, otocyon, and perhaps cony.

The klipspringer, which is called kainsi by the Hottentots and klip-bok by the Boers, is a small antelope that is widely distributed through South Africa. It may be found up the east coast through the province of Mozambique and is plentiful in Northern Zambesi, but in Cape Colony it is not as numerous as formerly. It cannot run very quickly on level ground, but when climbing a hill its marvelous agility is apparent; for it will race up the smooth face of slippery rocks, so steep that no other animal other than a baboon could find a footing there. Its fondness for a rocky country has led to its being called the "chamois of Africa." Klipspringer stalking in Africa is a very pretty sport, affording healthful exercise, frequently amid charming scenery.

The topi, according to some writers, "is nominally a hartebeest," that is, it is something like an antelope and yet much heavier, having to a certain extent characteristics that ally it to the family that includes the bovine species. It is a good-sized beast and sturdily built, and has a beautifully shaded skin of purplish tint, with a sheen on its coat which seems to change color in different lights like shot silk. Its distribution is curious. It is found near the coast and also far in the interior; yet there are wide regions where it is unknown. The flesh of the topi is excellent, furnishing the best meat for eating in some parts of Central Africa.

The hartebeests are large antelopes that go about in herds and are very swift. There are many varieties of these animals, although they are usually classified as hartebeests proper, bastard hartebeests, and gnus. Among the bastard hartebeests are the topi, already mentioned; the korrigum, and the tiang. The hartebeests are all more or less ungainly looking ruminants of comparatively large size, with naked muzzles, very small glands in the face below the eyes, and large valved nostrils, of which the lower lids are covered with a number of short bristly hairs. They have long-tufted or hairy tails and have peculiarly angled horns set at the extreme top of a very long face. In color they are either uniformly brown, or similarly colored with the addition of blackish or purplish patches on the face, shoulders, hind quarters, and lower portions of the limbs. They are sometimes domesticated, but usually are hunted for their flesh, which resembles beef.

The wildebeest is better known as the gnu, and of it there are the brindled species and the white-tailed gnu, with three distinct varieties of the first species. Wildebeests are described as grotesque-looking ruminants with disproportionately large heads, distinguished from other genera of hartebeests by the tufts of hair on their faces, their maned necks, very broad muzzles, doubly-curved smooth horns, and long horse-like tails. Their ground color varies from gray to dark brown, with or without transverse stripes, the long hair of the mane and tail being either black or white. From their peculiar appearance they have often been called horned horses.

Gazella is the name of a group of graceful little antelopes which are commonly known as gazelles, from the Arabic name of one of the species. They are found in the more open districts of Africa and are divided into about fifteen distinct species. Generally the color is sandy above and white below, and in all African species the face is marked with longitudinal dark and light streaks. Tufts of hair are usually developed on the knees and the tail is of medium length in the African species.

Impallas, or sometimes simply pallas, is the name given to certain antelopes. There are two African species known to science, the common impalla, and the Angolan impalla. Their general color is bright reddish brown, but paler along the lower part of the sides. The horns of the impallas are particularly graceful. They extend convex below and concave above, spreading evenly. They are described as most graceful and agile creatures. They display great activity when alarmed, flying through the scrub and bounding high over bushes, one after another, as the herd follows its leader in its headlong course; or, if surprised at close quarters in thick cover, the bush becomes suddenly alive with them, several often being in the air simultaneously in their first bewildered fright.

Dik-dik is the name given to a curious group of little antelopes which may be distinguished from all other forms by the more or less marked elongation of the muzzle, which is almost entirely covered with hair, and the presence of a tuft of long hair on the crown of the head. The tail is so short as to be almost rudimentary and the lateral hoofs are very small. Seven distinct species are known. They stand about 15 inches in height.

The otocyon is a small carnivorous animal quite like a fox. There are several species of this animal, one of which, called otocyon virgatus, is generally of a bright buff color and is new to science. Its skull is said to closely resemble that of the gray fox of our native fauna.

The many kinds of boks, such as the blesbok, bontebok, rhebok and others are almost all antelope or deer-like animals that have been so named by the Boers. Or similar characters are the bucks such as the bushbuck, reedbuck, waterbuck, etc., the name of which suggests English origin.

The cony is a small animal with fleshy pads in its toes by means of which it can climb with great agility among rocks and in large trees. Although comparatively small, being only about the size of a woodchuck, nevertheless, it has much the same structure as such very large animals as the rhinoceros. The cony is of interest on account of having been frequently mentioned in the Bible. It occurs only in Syria and certain parts of Africa, but no species of it is found in the United States.

THE WORLD'S PRODUCTION OF NICKEL.

THE world's production of nickel declined from 14,100 metric tons in 1907 to 12,800 metric tons in 1908. The production of nickel is confined almost entirely to the United States, Canada, Great Britain, Germany and France. The United States and Canada furnish nearly half the total quantity, and their production has increased, since 1900, more rapidly than that of Europe, as is shown in the following table, in which the quantities produced in the various countries are given in metric tons:

	Great Britain.	Germany.	France.	United States and Canada.	Total.
1900	1500	1400	1700	3000	7526
1901	1800	1700	1800	3600	8810
1902	1300	1600	1100	4700	8739
1903	1700	1600	1500	5100	9850
1904	2200	2000	1800	6000	12000
1905	3100	2700	2200	4500	12500
1906	3200	2800	1800	6500	14300
1907	3200	2600	1800	6500	14100
1908	2800	2600	1400	6000	12800

Nickel has no market, in the strict sense of the word. Its price depends on individual agreement and fluctuates greatly. The approximate average price per pound declined from about 48 cents in 1893 to 32 cents in 1896, since which date it has fluctuated between 32 and 37 cents.

A subway for Vienna is projected, according to the Zeitshrift des Oesterreichischen Ingenieur Vereines. This new system, which, if built, will be the first subway in the city, is designed to run in two lines, crossing each other at right angles in the center of the city. The project at present calls for municipal ownership and the construction of a large power plant, from which light and power are to be sold.

PHOTOGRAPHY SCIENTIFICALLY INTERPRETED.

CHEMICAL AND PHYSICAL CONSIDERATIONS.

BY DR. LUDWIG W. GUENTHER.

EVERYBODY who has even once taken a photograph or printed a negative has in so doing, perhaps unconsciously, brought into play a series of photochemical laws. At his first attempts he no doubt experienced some anxiety about having made the proper exposure, for this is, of course, the alpha and omega of all photographic processes. Too short an exposure will cause some details to be missed, too long an exposure will destroy contrasts. It is a matter of common knowledge that the negative must be developed and fixed in order to bring out and render permanent the invisible, latent image. In this development lies the immense value of Daguerre's and Talbot's invention with which they surprised the world seventy years ago (1839), and in this point is found the radical superiority of their method over all previous experiments in which the copying or "printing" of pictures had been accomplished, but never direct exposure in a camera. Before Daguerre and Talbot, exposure was continued until the image was visible in all its details, and this, of course, required infinitely more time than when the work of light was assisted or completed by a chemical reaction. The original discoverer of the fact that silver salts are sensitive to light was a German, Professor Schulze, of Halle.

The science dealing with the chemical reactions due to the influence of light is called photochemistry. We are always performing photochemical operations when we are doing photographic work, only in that case the scientific phase is less prominent than the artistic phase of picture-making: science becomes the handmaid of practical work. This ought not to be so, for without science we should not have attained the present perfection.

When we make a positive from a negative by means of a printing-out paper, such as aristo (gelatine) paper, collodion paper, or albumen paper, we can follow the process readily; sooner or later we reach the moment when we say, "That will do," and remove the printing frame from the light. This "enough" indicates the maximum of the process, the desired photochemical effect. What does it depend on? On light alone? No, it also depends on the length of exposure. Intuitively we use a shorter exposure if the light is strong and a longer one if the light is weak, that is to say the length of exposure will depend on the strength (intensity) of the light. We thus obtain the law of photochemical reciprocity, discovered by Bunsen and Roscoe about the middle of the last century and enunciated as follows: The photochemical effect E is in direct ratio to the product of light intensity I multiplied by length of exposure t, that is $E = It$. From this law it follows that if we have a constant source of light and desire to print negatives of different density, we must expose the longer, the denser the negative happens to be; or, conversely, if prints of the same quality are desired after a constant length of exposure, the denser negative will have to be exposed to light of greater intensity. This is a condition the busy photographer will often have to face. He will meet it either by placing the denser negatives nearer to the lamp or other source of light; or he may put one or more layers of tissue paper over the thinner negatives.

It is not difficult to observe this rule when using printing-out paper which, as stated above, allows the progress of printing to be watched; it is less easy to do this with paper for printing by gas light, a developing paper, the sensitiveness of which is low enough to allow it to be handled by the light of a gas burner or kerosene lamp, as long as the paper is not brought too near the light; the greatest difficulty, of course, is experienced with the highly sensitive dry plates. All sorts of apparatus have been recommended for accurately establishing the equilibrium between light intensity and length of exposure; the old infallible actinometer, the new ones devised by Hyde and Plaubel, the Agfa exposure table and Staeble's exposure table, they all serve this purpose, without however relieving the amateur of the final delicate estimating.

The relations between light intensity and length of exposure have found a practical application in a case where the keenest eye would have failed, even when assisted by the best instruments, in astronomy. By substituting a camera for the eye-piece of one of our modern giant telescopes, even very faint stars may be photographed under a prolonged exposure. In this work a leading part has been taken by the Heidelberg Astrophysical Institute, under the direction of Professor Max Wolf.

There is, however, a lower limit of light intensity below which even the longest exposure will have no effect. This limit is called the critical value of the sensitive plate.

For practical purposes it is of the utmost importance to know the sensitiveness of a plate, or, more properly speaking, its maximum sensitiveness. This is the function of sensitometry, a science also founded by Bunsen and Roscoe and developed to its modern condition by Vogel, Eder, Warnercke and Scheiner. The sensitive plate is exposed for a predetermined length of time in streaks or stripes, the sensitive layer being covered with a glass plate having squares differing as to perviousness to light and suitably numbered. The simplest way of producing these squares is to cut out of tissue paper strips of the same width but different length, and superposing these with one end in registry so that the other end will overlap in step-wise fashion. The last (highest) number just faintly visible after strong development is the degree of sensitiveness in units of the particular scale adopted, such as Scheiner's or Warnercke's. This kind of sensitometry is successfully applicable only to highly sensitive plates and to diapositive plates, but not to orthochromatic plates. With the latter, it is necessary to resort to a supplementary spectro-photographic determination.

Working with highly sensitive plates is especially difficult because the allowable deviation from the absolutely correct length of exposure becomes less and less as sensitiveness is increased. A most reliable plate for amateurs, where snapshots are not intended, is the silver eosin plate of Vogel and Obernetter, manufactured by Otto Perutz of Munich.

This silver eosin plate is the direct result of a very remarkable invention of H. W. Vogel, which culminates in the possibility of rendering silver bromid (the sensitive material of dry plates) sensitive to all light rays of the spectrum, that is to say, orthochromatic, whereas hitherto silver bromid would be affected only by the blue, violet, and ultra-violet rays. These rays were formerly known as chemical rays, and are still referred to as such sometimes, but improperly. The statement of this invention leads us to another photochemical law, the so-called law of absorption, first perceived by Grothuss, and definitely formulated by Draper. Of what avail is the very strongest exposure if the light rays are not absorbed so as to exert a chemical action? Who knows what bodies sensitive to light may yet be discovered if we only learn to make them sensitive to light, to sensitize them optically? Sensitizing is accomplished by dipping the plate in dilute solutions of coloring matters, for instance eosin.

In all photochemical processes there must be work done by light; it must vanish as such and re-appear in a different form, for instance, as heat, electricity, or chemical decomposition. In the last-named case we are dealing with the so-called photochemical extruction (extinguishing).

Another law is that of photochemical induction; it requires a certain amount of preliminary or inductive exposure before the starting of the chemical process. As a matter of fact, if a dry plate is exposed for a very short time to diffuse light or to red light, its sensitiveness is increased materially. Incidentally, it may be noted that a similar effect may be produced by the action of heat.

It is not immaterial, however, whether we employ a single long exposure or a series of very short exposures of an aggregate length equal to the long exposure. The result will not be the same, but in the later case (of the intermittent exposure) under-exposure will be observed and it would seem as if the plate after each light impulse found time to recover and to go back toward its original condition. This return of the plate was ascertained after a lapse of several years even with plates which had received the proper length of exposure.

The developing process itself, which brings to view the latent image, the initially invisible light impression, really leads to the same final result as a long exposure continued until the image is fully visible; in one case as in the other silver, that is dark silver, is precipitated from the white silver chlorid or silver bromid. Chlorin or bromin escapes as a gas. In the printing-out process and in developing as well, chlorin and bromin combine chemically; yet there is a material difference between the two processes. The printing-out process may be considered a typical case of a reaction proceeding in the presence of light; the developing process, on the other hand is a typical case of reaction proceeding in the dark. With the aid of development we are able to imitate artificially, even under complete exclusion of light, the light-process of printing-out and its products.

The relation between reaction in the presence of light and reaction proceeding in the dark is particularly instructive in cases where the process is reversible or cyclic. Suppose we take, say silver chlorid and put equal quantities in glass vessels of equal volumes, exhaust the air from some of these vessels to different degrees and fill others with air under various pressures, carefully seal both kinds of vessels and expose them to light for the same length of time simultaneously with other, unsealed vessels and some sealed under atmospheric pressure; the darkening of the silver chlorid will be a measure for its chemical decomposition by the action of light; or in other words, for the work done by the light. We shall find that the substances enclosed in exhausted vessels have become darkest, the more so the greater the vacuum. With the substance held under pressure, the darkening decreases with the increase of pressure. The unsealed vessels we shall consider standard vessels. If then we bring all the vessels back into the dark we shall find after some time that in some cases the darkening effect has disappeared partly, the substances sealed under increased pressure have again become quite white, while those under a vacuum have only become somewhat lighter in color. The substances in the open vessels have remained unaltered (dark), for in this case the liberated chlorin has escaped into the surrounding air, and the process is no longer reversible.

How shall we explain this phenomenon? Light decomposes the silver chlorid and chlorin is liberated as a gas to the extent it is able to overcome atmospheric pressure. It is, therefore, readily understood that decomposition proceeds more quickly and farther in the exhausted vessels than in those under increased pressure. The liberation of chlorin will continue until the dissociation pressure of chlorin, produced by the action of light above the silver chlorid, reaches a certain maximum value. We then have a condition of light-equilibrium which can be altered by changing the intensity of light. If we remove the light energy, the pressure will force chlorin back into re-combination with silver until the equilibrium in the dark is restored, and this takes place most rapidly and most completely under increased pressure.

Chemical pressure may be substituted for the mechanical or physical pressure of the example given above. Thus these chemical sensitizers, for instance absorptives of chlorin, such as silver nitral, tannin, etc., the addition of which to silver chlorid diminishes the dissolution pressure of chlorin, and on the other hand oxidizing bodies, chlorin and the like, will increase this pressure. With the "Rembrand" printing-out paper, which contains a chromate, the decomposition or darkening process is retarded appreciably. This paper is used to obtain good prints from weak negatives.

The doctrine of equilibrium conditions during chemical reactions is termed the law of chemical mass effect.

Only the reversible cyclic process enables us to accurately measure the work done by any energy, such as that of light, by determining the pressure which is required to prevent a certain work, as in the case of light, the darkening of silver chlorid.

E. Becquerel's photo-electric cell is a much more accurate instrument for measuring photochemical decomposition. As electrodes, the means for converting luminous energy into electrical energy, we use bright sheet silver plates, dipped for an instant into a solution giving off chlorin, for example, a solution of chlorin, or one containing mercury chlorid or copper chlorid; this causes the plates to become covered with a thin film of silver subchlorid, which is dark and sensitive to light. The electrodes are placed in a conducting liquid, such as a solution of common salt. If the two electrodes are connected and a galvanometer included in this connection, then by exposing one electrode to light while the other is protected by an interposed dark screen, a current will be generated and indicated by the deviation of the galvanometer needle. At the exposed electrode chlorin is liberated, which travels to the unexposed electrode and there gives off its electrical charge which returns to the first electrode through the connecting wire, thus producing the electric current. As soon as the pressure of light ceases, the chlorin stored

at the unexposed electrode returns by a diffusion process, and a current of opposite direction flows in the dark. Luther has based some interesting experiments upon these observations.

We still have to answer the question: What is the nature of the photochemical effect? If we are dealing with stable substances which have been formed under considerable evolution of energy (heat), that is, bodies containing stored energy, we have to do work against this energy, the so-called chemical affinity, and this work must be at least equal to the heat developed. This is the case when silver chlorid is decomposed. There also exist compounds undergoing slow spontaneous decomposition, as the chromated gelatine used in pigment printing; in this case the action of light will accelerate decomposition. Finally, light is capable of starting reactions, that is, it will enable some other energy to act and to carry the process to completion. The short preliminary exposure of dry plates followed by the chemical reaction of development may be cited as an instance of this third type.

Now, what is the essence of the chemical action of light? As we attack this question, we have to admit at the outset that only hypotheses can be offered.

The action of light has been considered a catalytic one; among others, Wilhelm Ostwald has championed this explanation. Catalysis is a theory developed by physical chemistry to account for the peculiar effect of certain bodies, such as finely-divided metals, bacteria, etc., which in very small quantities will suffice to bring about a reaction between unlimited amounts of other substances. Finely divided platinum, so-called platinum sponge, is capable of causing the otherwise stable mixture of hydrogen and oxygen to combine just as a spark would do. To consider light as a catalytic agent is according to K. Schaum open only to one objection, which is that a catalytic agent always remains unaltered, whereas light is destroyed, or rather converted into chemical energy. Other scientists, as Eder and Quincke, have suggested a vibration of the particles of the sensitive molecule in unison with the light. As a matter of fact, light is energy of motion and is well able to disrupt the complex of atoms by continued impact.

Nernst and Arrhenius have attempted explanations based upon the electro-magnetic theory of light.

What factors govern the absorption of luminous rays? Not the least important factor is the color of the article exposed to light. Let us look at the leaf of a tree; it appears green. Why? Because, from the spectrum of white light, it absorbs all red rays, but reflects the others, which together form green. This general physical explanation of the nature of color finds its complement in the observation that red light is most favorable to the assimilation of carbon, the important chemical process which enables a plant to grow. Green light, however, is just as incapable of maintaining plant life as darkness, the total absence of light.

Whereas in the case just explained colored light leads to the formation of a substance of a complementary color (chlorophyll), there are bodies which assume colors corresponding to those of the light falling upon them. Silver chlorid may serve as an example, especially if it has become dark by exposure to light. Experiments may be made readily with silver chlorid (printing-out) papers found on the market, only the exposure should be long enough. Under a red glass the silver chlorid, which was first of a dark brownish violet, becomes red, and this again blue if exposed under a blue glass, and so forth. Why this apparent contradiction of the facts first explained? The answer is given by Professor Wiener's theory of substances sensitive to light absorptively. Such substances are mixtures of the most varied light-sensitive coloring matters. Those that best reflect the light to which the substance is exposed, that is, those of the same color as the light, are preserved; all those of a different color are destroyed more or less, most of all those of the complementary color; that is, the green coloring matters, in the case of red light. The final result is a color similar to that of the light. The author has succeeded in producing by a purely chemical process, various coloring matters of the hypothetical mixture of coloring matters, thus confirming Wiener's theory.

As interesting as photochemical investigations may be, they are difficult to conduct; results may be completely altered by a number of factors which often appear to be of very inferior importance, and thus a second investigator may frequently find quite different results from the first. This one assertion, however, I may make without being charged with unwarranted confidence:

That photochemistry has a great future, and more particularly the organic reactions offer great interest from the point of view of the physiologist and of the biochemist. If in our remarks we have gone a roundabout way and spoken first of inorganic reactions, this has been done because these reactions permit of a more readily understood explanation in view of the well-known photographic processes.—Umschau.

ENGINEERING NOTES.

The Connecticut River bridge at Hartford, over which traffic is now and has been passing since November of last year, is one of the most attractive stone structures in this country, and for this reason the report that cracks have appeared in several parts of it has attracted considerable attention. As a matter of fact, there are no cracks in the bridge proper, save such as are apt to occur in the pointing due to temperature cracks that must be expected in nearly a quarter of a mile of continuous masonry. The piers for the bridge are all founded on rock, except that of the east abutment, which is heavily piled, and all of these piers may be regarded as solid as they can be made by modern engineering. Cracks have developed, however, in the easterly north wing wall, a continuation of the last arch spandrel wall, despite the precaution taken to excessively load the wall before the coping was put on, which has held nearly two years without developing any crack in the wall. There is no theory at which the engineers can arrive to account for the bad crack opening up after the completion of the work. This wall has a separate foundation from that of the abutment, on sufficient piles, cut off about 8 feet higher than those in the abutment. It is a matter of no serious moment, being simply a wall less than 50 feet long, and at worst can be readily relaid without affecting the bridge, with which it has nothing to do. On the west side, high retaining walls flank the abutment on either side of it, and at right angles thereto the north flank is not yet built. The south flank is entirely a separate structure from the bridge, the abutment of which is on rock. The wing wall is on piles, and a so-called crack shows up between the wall and the abutment, between which there is no bond, as there never should be between a pier and a wing founded on different bottoms, or with different pressures. The separation crack between this wall and the abutment is a mere matter of repointing when convenient.—Engineering Record.

A change in signaling, consisting of a new position of the signal arm for "proceed" has been adopted as standard by the Baltimore and Ohio Railway, and will be used in all future installations. The new position, instead of being below the horizontal, as heretofore, is above. No change, however, has been made in the stop indication, the arm being horizontal, or at right angles to the mast. The "proceed, caution" indication is given by the arm in the 45 degree position above the horizontal, as compared with a similar position below the horizontal under the old method. The "proceed, clear" indication is given by the arm in the vertical position outside the line of the mast above the horizontal, whereas under the old method this sign was indicated by a similar position below the horizontal. The operating officials believe that the upper quadrant system provides a more distinct aspect than under the old method. The first test of the new method was begun about three years ago, and though a large number of installations of this type of signal has been made during the past two years, it was not finally adopted as standard until recently.

Mexico, states a contemporary, holds the fifth position in the production of quicksilver in the world, but falls short by a considerable amount of producing enough to supply the home market. Prior to the introduction of the cyanide process for the treatment of the silver ores the importation of quicksilver, known in the Spanish as "asogue," was very heavy, and the necessity of having this metal for the patio process was so great that the Government removed all taxes on quicksilver mining, both federal and state, and provided for the free admission of quicksilver into the country. This same law is enforced to-day, and is one of the causes stimulating the new developments in the Mexico quicksilver districts. The falling off of production in other parts of the world has turned attention to the Mexican districts, and the prospects of greater activity in quicksilver mining in Mexico are very good.

The compressive strength of concrete when reinforced with separate transverse ties or iron wire arranged in lattice form, and when mixed with scraps of iron wire, has been investigated by Mr. W. P. Nekrassow, of St. Petersburg. He reported to the Copenhagen Congress of the International Association for Testing Materials that when the wires of the lattice are from 4 mm. to 3 mm. or less in diameter, the increased resistance to crushing is in every case as great as that of hoops. The same is true with scraps of iron wire when they are 0.5 mm. to 0.25 mm. in diameter.

The first section of the Shanghai-Hangchow-Ningpo Railway, which extends from Shanghai to Fengch'ing, a distance of 38 miles, was opened for traffic on May 30th last. This line was built under Chinese engineers. The preliminary survey of the line was made in the winter of 1907. There are 10 stations and 48 steel bridges on this section. The longest bridges have spans of 440 feet, 400 feet and 200 feet, respectively. The average cost of construction was $35,000 per mile.

TRADE NOTES AND FORMULÆ.

Simple Reliable Black Stain for Brass.—Over parts of carbonate of copper (commercial), pour parts of 10 per cent spirits of sal ammoniac and allow it to stand in a dark colored, closed bottle, over night. Some carbonate of copper must remain undissolved (we may possibly have to add some to insure this). The whole is diluted with 25 parts of water and is then ready for use. The brass object to be colored black must be scoured absolutely free from grease; it is best to beat it to redness, boil it out and pickle it in the "bright dip." Then rinse it well and lay it for 3 to 5 minutes in the black stain. The object will at first turn bluish, then brown, finally deep black as if oxidized. At this stage it should be removed; if allowed to remain longer in the stain, the fine color will disappear. Then dry it at once in sawdust and zaponize the object (i. e. cover it with celluloid varnish). After a long time the stain becomes inoperative, but otherwise, if the object has been well scoured, it is reliable.

Angostura Bitters (formula of Siegert).—Cloves, parts, angelica root 3 parts, ginger root 3 parts, galangal root 15 parts, gentien root 15 parts, zedvary root 15 parts, small cardamoms 20 parts, cassia parts, bitter orange peel 25 parts, tonka beans parts, red sandal wood 80 parts, brown Peruvian bark 100 parts. Coarsely crush and cut all the ingredients and extract for 15 days with 5,000 parts of 60 per cent alcohol; press, strain and filter. Then add 200 parts of sugar color, 500 parts of Malaga wine and after settling filter again.—Barsch, Chem. Tech. Lexikon.

Finish for Leather.—*a*. 125 parts brown shellac is dissolved in a boiling solution of 26 parts of borax and 3 parts of caustic potash, the powdered shellac having been previously moistened with a little ammonia. *b*. 56 parts of logwood extract solution of 30 deg. B. (approximately 400 parts of extract per 1,000 parts), 10 parts glycerine, 10 to 20 parts of aniline black and methyl blue, dissolved in 300 parts of water. Mix this with the shellac solution, add a mixture of 50 parts of pyrolignate of iron at 20 deg. B and 90 parts of water and add a little oil of mibrane and oil of thyme.

Amalgamating salt in fluid form is prepared (*a*) by dissolving 1 part quicksilver in a mixture of 1 part nitric acid and 3 parts hydrochloric acid. The solution is effected in a porcelain dish in the sand-bath, under a well ventilated roof, attached, like a forge hood, to the chimney. (*b*) Dissolve 8 parts commercial corrosive sublimate in 100 parts of water and add 10 parts of hydrochloric acid. Dip the zinc pieces in for an instant, rinse them and brush them off. (May be applied with either a sponge or a brush; never touch with the naked hands.)

Aluminium Rronze Alloy.—*a*. 90 parts copper, 10 parts aluminum, 1/6 per cent of an alloy of 20 parts nickel, 20 parts copper, 30 parts tin, and 7 parts aluminum. *b*. Copper plate is electrolytically coated with 1 to 10 per cent of aluminum, then melted together with 1 per cent of the following alloy: Alloy—20 parts nickel, 2 parts copper, melted under a layer of charcoal, next, another 18 parts of copper mixed in. Stir up with an earthenware stirrer 53 parts tin and finally 7 parts of aluminum to be added. Cast in bars.

Acid Varnish for Heater.—Gall nuts 200 parts, logwood 30 parts, water 200 parts are boiled for two hours, the evaporated water being replaced from time to time; then pass it through a filter. In the filtrate dissolve 40 parts of green vitriol and 200 parts of brown syrup and boil the fluid again until it begins to thicken. Then add a solution of 10 parts of shellac in 30 parts of strong spirits. Must be kept in tightly closed bottles.

Paint That Will Stand Dampness.—*a* 2 parts coal tar, 2 parts pitch and 1 part of a mixture of burned lime and rosin are to be melted together and while warm applied several times to the thoroughly dried wood. The last coat to be sanded before it is completely dry. *b*. Melt 12 parts of rosin in an iron kettle, mix and when these ingredients are fluid add as much ocher or umber as may be necessary to make the mixture cover. Then dip the brush in it and coat the object as thinly as possible, repeating the application in a few days.

TABLE OF CONTENTS